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DEPARTMENT OF SCIENCE AND ART.



GOVERNMENT SCHOOL OF SCIENCE APPLIED  
TO THE ARTS,

Museum of Irish Industry, Stephen's-green, East.

## PROGRAMME

OF

## EDUCATIONAL ARRANGEMENTS

FOR THE

SESSION OF 1856-1857.

THE SESSION WILL BE OPENED ON THE 9TH OF OCTOBER  
BY AN ADDRESS FROM THE DIRECTOR,

SIR ROBERT KANE.

## DUBLIN:

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1856.



COLLEGE OF TRADE

DEPARTMENT OF COMMERCE AND THE

COLLEGE OF TRADE SCHOOL OF SCIENCE AND  
TO THE ARTS

COLLEGE OF TRADE SCHOOL OF SCIENCE AND  
TO THE ARTS

## PROGRAMME

TO

## EDUCATIONAL ARRANGEMENTS

FOR THE

SESSION OF 1886-1887

THE SCHOOL WILL BE OPENED ON THE 1ST OF OCTOBER  
AT THE ADDRESS OF THE COLLEGE

SIR RONALD EYRE

## DUITS

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SYLLABUS  
OF THE  
COURSE OF LECTURES.

*(The figures refer to the pages of the detailed Syllabus.)*

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## PROGRAME.

THE systematic courses of scientific lectures delivered in the theatre of the Museum of Irish Industry during the Sessions of 1854-1855, and 1855-1856, may be considered as the first fully organized arrangement carried out in Dublin to provide those who are occupied in the day time with the means of employing their leisure hours in the evening in learning thoroughly the more practically useful branches of science. The success of the experiment, notwithstanding that the advantages offered could not at the outset have become generally known, has been such as to fully call for a continuation of it during the ensuing session.

But while the education of that numerous and important portion of the public will be provided for, it is proposed to extend still further the utility of those educational arrangements for the future, by establishing corresponding courses of lectures on the several departments of applied science, to be delivered during the day.

### DAY AND EVENING CLASSES.

In the session of 1856-1857, accordingly, there will be two distinct and independent series of courses of lectures, the one to be delivered in the day time, the other in the evening. Each day course will consist of 32 lectures, and each evening course of 20 lectures.

### PLACE OF DELIVERY.

In addition to the systematic courses of lectures given during the last two years, and which were wholly delivered in the theatre of the Museum of Irish Industry, each professor gave an additional course of twelve lectures of a popular character in the theatre of the Royal Dublin Society, under the direction of the Committee of Lectures, conjointly appointed by the Government and the Royal Dublin Society. With the view of rendering those lectures of greater utility, it was proposed to bring them into connexion with the systematic courses. The joint Committee, under whose direction the arrangements for those lectures were carried out, having at once sanctioned this connexion, the first twelve lectures of each systematic course of day lectures have been approved of by them accordingly, and will be delivered in the theatre of the Royal Dublin Society, in lieu of the popular lectures hitherto delivered there. The remaining twenty lectures of each day course will be delivered in the theatre of the Museum of Irish Industry.

Each professor has hitherto also given a course of evening popular lectures in the theatre of the Museum of Irish Industry. In future it is proposed to make these lectures part of the evening systematic courses; but in order to avoid the inconvenience which would arise

of having two lectures on the same day in the same theatre, two of the evening courses will be wholly delivered in the theatre of the Royal Dublin Society. Accordingly, during the delivery of day lectures in the theatre of the Royal Dublin Society, any evening lectures which may be given during the same period will be delivered in the theatre of the Museum of Irish Industry; and when the latter theatre will be occupied during the day, the evening lectures will be given in the theatre of the Royal Dublin Society.

In this association of all the lectures of a popular character with the systematic ones, the privileges which the public has hitherto enjoyed will not be interfered with, while it is hoped that the utility of the lectures will thereby be very greatly increased.

#### TIME AND MANNER OF DELIVERY.

As a large number of persons will attend these courses whose time and attention will necessarily be more or less occupied with business, it has been thought judicious that lectures on two different subjects should not alternate as heretofore, but that each course, or division of a course, should end before a different course be commenced. This arrangement, which will prevent the continued alternation of different subjects, and consequent danger of confusion of ideas, will, it is hoped, be of equal advantage to those students who can devote their whole time to study.

The session will commence on Thursday, the 9th of October, 1856, and end on Thursday, June 11th, 1857.

On the 9th of October, the Director, Sir R. Kane, will deliver an opening address at four o'clock, p.m., in the theatre of the Museum of Irish Industry.

#### DAY CLASSES—*Before Christmas.*

*Physics.*—On Monday, the 13th of October, the Professor of Physics will commence his course in the theatre of the Royal Dublin Society, at four o'clock, p.m., to be continued every day, Saturday excepted, until he shall have completed the first part of his course, consisting of twelve lectures.

*Chemistry.*—On Wednesday, October 29th, the Professor of Chemistry will commence his course in the theatre of the Royal Dublin Society, at four o'clock, p.m., to be continued every day, Saturday excepted, until he shall have completed the first part of his course, consisting of twelve lectures.

*Natural History*—(*Part 1, Zoology.*)—On Monday, November 17th, the Professor of Natural History will commence a course of twelve lectures on Zoology (being the first part of his general course), at four o'clock, p.m., to be continued every day, except Saturday, until completed.

*Geology*—(*Part 1, Physical Geography.*)—On Wednesday, December 3rd, the Professor of Geology will commence a course of twelve lectures on Physical Geography (being the first of his general course), at four o'clock, p.m., to be continued every day, except Saturday, until completed.

*After Christmas.*

*Physics.*—On Monday, January 5th, 1857, the Professor of Physics will resume his course at four o'clock, p.m., in the theatre of the Museum of Irish Industry, and will continue, at the same place and hour, on every day in the week, except Saturday, until the course be completed. The examination for prizes in this class will be held on Saturday, January 31st.

*Chemistry.*—On Monday, February 2nd, the Professor of Chemistry will resume his course at four o'clock, p.m., in the theatre of the Museum of Irish Industry, and will continue, at the same place and hour, on every day in the week, except Saturday, until the course be completed.

The examination for prizes in this class will be held on Saturday, February 28th.

*Geology.*—On Monday, March 2nd, the Professor of Geology will resume his course at four o'clock, p.m., in the theatre of the Museum of Irish Industry, and will continue, at the same place and hour, on every day in the week, except Saturday, until the course be completed.

The examination for prizes in this class will be held on Saturday, March 28th.

*Natural History.*—On Monday, March 30th, the Professor of Natural History will resume his course at four o'clock, p.m., in the theatre of the Museum of Irish Industry, and will continue, at the same place and hour, on every day in the week, except Saturday, and during the Easter recess, until the course be completed.

The examination for prizes in this class will be held on Saturday, May 2nd.

*EVENING CLASSES—Before Christmas.*

*Geology.*—The Professor of Geology will commence his course of evening lectures on Monday, October 27th, at eight o'clock, p.m., in the theatre of the Museum of Irish Industry, and will continue, at the same place and hour, on every day of the week, except Saturday, until the course be completed.

The examination for prizes in this class will be held on Monday, November 24th.

*Chemistry.*—The Professor of Chemistry will commence his course of evening lectures on Tuesday, November 25th, at eight o'clock, p.m., in the theatre of the Museum of Irish Industry, and will continue, at the same place and hour, on every day of the week, except Saturday, until the course be completed.

The examination for prizes in this class will be held on Tuesday, December 23rd.

*After Christmas.*

*Physics.*—The Professor of Physics will commence his course of evening lectures on Monday, March 2nd, at eight o'clock, p.m., in the theatre of the Royal Dublin Society, and will continue, at the same

place and hour, on every day of the week, except Saturday, until the course be completed.

The examination for prizes in this class will be held on Monday, March 30th.

*Natural History.*—The Professor of Natural History will commence a course of lectures on Botany, on Monday, May 4th, at eight o'clock, P.M., in the theatre of the Royal Dublin Society, and to be continued, at the same place and hour, on every day of the week, except Saturday, until the course be completed.

The examination for prizes in this class will be held on Monday, June 1st.

A table of the days, hours, and places of delivery of the lectures, arranged as an almanac for each month, is appended, and will serve as a useful guide to students and the public generally.

#### FEES.

As the first twelve lectures of the day courses will represent the popular lectures hitherto delivered, they will be free to the public; for the remaining twenty lectures a fee of 3s. 6d. will be charged.

The first twelve lectures of the evening course, representing the popular evening lectures hitherto delivered in the Museum of Irish Industry, will likewise be free to the public; for the remaining eight a fee of 6d. will be charged, no matter where delivered.

#### PRIZES.

At the termination of each course of day lectures an examination will be held of such as present themselves, and have complied with the regulations as to registration and attendance hereinafter stated, when the following prizes will be awarded to the most distinguished students:—

First Prize,	£2
Second do.,	£1
Third do.,	£1

Similar examinations will be held at the end of each evening course, and prizes equal in amount to those allocated to the corresponding day classes will be awarded.

Previously to the close of the session a joint examination will be held in all of the subjects lectured upon in the school, open to all students of the day or evening classes who shall have passed one, at least, of the special examinations held during the session. The following prizes will be awarded to the three students who shall most distinguish themselves at this joint examination:—

First Prize,	£10
Second do.,	£5
Third do.,	£3

The session will be closed on Thursday, June 11th, by an address from the Director, Sir Robert Kane, when the public award of the prizes and certificates will take place.

## CERTIFICATES.

Certificates will be granted to those students of the day or evening classes, without distinction, who shall present themselves at the general examinations, and whose answering in all the subjects shall be deemed satisfactory.

The value of certificates testifying to a knowledge of the more practically useful branches of science will become daily more and more recognised; and already a very large number of the leading manufacturers of the United Kingdom have agreed to accept similar certificates as one of the highest testimonials which can be presented by persons seeking employment in their establishments. Every student should, therefore, strive to win such a certificate.

## REGISTRATION.

No person will be considered eligible to compete for prizes or certificates, except he or she shall have registered themselves as students on or before October 13th, and paid the fees charged, according to the class which it is intended to join.

The office for registration will be at the Museum of Irish Industry, where Mr. Penny will receive the names of all who are desirous of entering as students, and give admission tickets. Students may register for one or more of the courses, and compete for the special prizes allocated to those courses, but can only become eligible for a certificate by registration for, and attendance upon, all the courses.

## PRACTICAL INSTRUCTION.

*Chemistry.*—The chemical laboratory will be opened to students during the session, and lectures will be given upon analytical chemistry especially with a view to its application to manufactures. (The reader is referred to the programme of laboratory arrangements, page 48, for information as to fees, &c.)

*Botany.*—The Professor of Natural History proposes to hold a series of excursions for herborizations during the months of April and May. The days on which these excursions will take place will be subsequently decided upon, and due notice will be given to the classes by the professor.

*Geology.*—The Professor of Geology will also make some excursions, for the purpose of giving such students as can accompany him practical lessons upon the method of observation in the field. The Professor will arrange with his classes as to the time of his holding these excursions.

## EVENING ADMISSION TO THE GALLERIES AND LIBRARY OF THE MUSEUM OF IRISH INDUSTRY.

Nothing tends so materially to familiarize the mind with scientific names, and to impress upon the memory the information acquired from books and lectures, as the examination of the objects themselves, the study of whose properties or forms constitutes the basis of the experimental and observation sciences. This is especially true of natural history and geology, and, perhaps in an equal

degree, of chemistry in its applications to industry. The collections illustrative of chemical compounds and chemical manufactures, and of geology, now in the galleries of the Museum of Irish Industry, are sufficiently extensive to be useful in this way. With a view, accordingly, of making them contribute as far as possible to public education generally, and especially to the development of the system of instruction established in the School of Arts and Manufactures, the galleries will be lighted with gas, and opened to the public on all the evenings of lecture during the session.

With a view of facilitating the studies of those students who are occupied during the day, and cannot therefore visit any public library, access will be allowed to the library of the Museum of Irish Industry, which is provided with a number of suitable books in each department of science, selected by the respective professors. This library will be opened during the sessions at times and hours to be hereafter determined. The privilege of reading in this library must necessarily be exclusively confined to those students who desire to qualify for certificates by attendance upon all the courses, in one or other class, given during the session.

#### RECOMMENDATIONS TO STUDENTS ABOUT THEIR PRELIMINARY STUDIES.

The best preparations for the study of any branch of science is the study of mathematics, not merely because it is itself the first of the fundamental sciences, and in some cases the most powerful and indispensable instrument of research, but even as a mere mental exercise. A familiarity with mathematical reasoning usually gives more definiteness and exactness of ideas, and leads the student to disregard the usual vague and loose statements which the untrained mind is apt to accept as science, while it teaches him to set most value in the experimental sciences upon numerical relations, not only as the most important in a theoretical point of view, but also in a practical one.

A knowledge of the four principal operations of arithmetic (addition, subtraction, multiplication, and division), vulgar and decimal fractions, the extraction of square and cube roots, ratio and proportion, and the elements of geometry, will enable a person to acquire a very good knowledge of experimental physics and chemistry. Without this amount of knowledge, at least, many important points in both branches of science must be unintelligible, or at best must be very imperfectly understood.

And as it is impossible to have an accurate knowledge of animal and vegetable physiology, which are the basis of the other divisions of natural history, or of geology, without some previous knowledge of experimental physics and chemistry, this amount of elementary mathematics is equally necessary to the student who desires to pursue in an especial manner those branches of science.

There is one very simple truth which it is very desirable should be impressed upon the minds of students—namely, that in order to apply science to industry, it must be first learned; and that, con-

sequently, the impression which commonly prevails, and which some, who ought not to do so, have helped to foster, that there is a kind of inferior science adapted for practical persons, is perfectly erroneous. Indeed, no one requires to know science so thoroughly as he who intends to apply it in his business. The kind of science which is capable of being applied to industry with advantage must therefore be, in reality, of a far higher character than what is required as an element of general education.

Persons who intend to register themselves as students of the School of Arts and Manufacture, with a view of applying the knowledge of science which they may acquire in some of the various branches of industry, such as mining, the construction of machines, textile and chemical manufactures, agriculture, &c., will do well to remember, that although the amount of mathematics mentioned above will enable them to acquire a vast amount of information in the subjects taught during the session, it will be far from sufficient to enable them to apply it with profit in industry. Such questions as the strength of materials; the flow of water, steam, or gas, through pipes; the construction of water-wheels and turbines; or the theory of machines in general, and similar questions which perpetually present themselves to the manufacturer, require for their solution a considerable amount of mathematical knowledge. While it is to be hoped that no one will be discouraged from joining the classes of the ensuing session because they may not have previously studied the elementary mathematics, all who desire to acquire that accurate knowledge which alone is practically useful, should endeavour, either by self-instruction, or through the many facilities which exist for the purpose, to learn, at least, the most indispensable branches of elementary mathematics.

With a view of pointing out the extent of mathematics which it would be desirable that students who intend to become mining engineers, ship-builders, machinists, or managers of factories generally, should possess, before commencing the study of the experimental sciences, and of guiding those who desire, in the mean time, or in future years, to reach this standard of preparation by self-instruction or otherwise, the following syllabus of a course of elementary mathematics is added. Such a course would take the student as far as the calculus, and would enable him to understand all lectures upon mechanics, staties, and dynamics, and make use of the generality of text books upon those subjects. Before entering upon the course of study the student would derive great advantage from the reading of some work on logic of the character of the "System of Logic," by J. S. Mill, or Thompson's "Laws of Thought."

SYLLABUS OF A COURSE OF ELEMENTARY MATHEMATICS, PREPARATORY TO THE STUDY OF THE PHYSICAL AND NATURAL SCIENCES, AND OF THEIR APPLICATION TO INDUSTRY.

*Arithmetic.*—Numeration and notation. *Integral Numbers* :—The four principal operations of arithmetic with whole numbers (addition, subtraction, multiplication, and division). Determination of

the greatest common divisor of two or more numbers, and the simplest common multiple. *Fractions* :—1° *Vulgar Fractions*—Formation of vulgar fractions; the four principal operations with them. 2° *Decimal Fractions*—Distinction between vulgar and decimal fractions; the four principal operations with decimal fractions; conversion of vulgar fractions into decimal fractions, and the reverse.

Extraction of roots.

Ratio and proportion.

*Geometry*.—1° *Plane Geometry*—Properties of lines and angles. Properties of triangles and quadrilateral figures. Ratios and proportions. Geometry of the circle, and the measure of angles. Regular polygons, and the measure of the circle.

2° *Solid Geometry*.—Intersection of planes—solid angles. Solids bounded by planes :—The parallelopiped; polyhedrons. The three round bodies :—The cylinder, cone, and sphere. Properties of the sphere and spherical triangles.

Or the whole of Euclid's Elements of Geometry.

*Elements of Geometrical Analysis*.

*Algebra*.—The four rules with monomes and polynomes. Simple powers and roots. The greatest common measure, and the least common multiple. Fractions.

Equations of the first degree, including one unknown quantity. Equations of the first degree, including two or more unknown quantities.

Arithmetical progression. Geometrical progression. Permutations and combinations. Series and indeterminate co-efficients. Binomial theorem.

Equations of the second degree. Exponential equations. Exponential and logarithmic series. Use of logarithms.

Classification of algebraical expressions and consequences.

Relation between number and magnitude.

*Trigonometry*.—Definitions. Relations of trigonometrical lines. Relation between sines, cosines, &c., of sums, and differences of angles. Solution of plane triangles.

*Elements of Analytical Geometry*.—Application of algebra to the theory of Curves :—Straight lines; transformation of co-ordinates; lines of the second order, or the conic sections. Application of algebra to the theory of Surfaces :—The straight line in space. The plane. The sphere, cylinder, and cone. Surfaces of revolution. Surfaces of the second order.

*Descriptive Geometry*.—Projection of lines, of planes, and of curved surfaces. Intersections of lines, planes, and surfaces. Applications to cylindrical, conical and spherical surfaces. Skew surfaces. Theory of ordinary perspective and of isometrical perspective. Theory of shadows.

NOTE.—The following notes are given to serve as a guide to the student in the study of the subjects mentioned in the preceding list of subjects of instruction.

1st.—*Arithmetical operations*.—Addition, subtraction, multiplication, division, and extraction of roots.

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second letters I—second analogy lo I—second to the following—no more  
—intensity, and in position all to no more than—given to extre—  
—olders of older—minimally—abiles that suffice for the  
—of course to the best—no more than—no more than—no more than—  
Motion in Machinery—  
2011/2011

## DETAILED SYLLABUS.

[The object in view in drawing up this Syllabus on so much more enlarged a plan than that usually followed, is to provide the student with such an index to each branch of science, that however differently the text-book which he employs may be arranged, he may still be able to follow in his reading the order of subjects adopted by the professor. It is also intended to keep the sequence of subjects before the student's mind and familiarize him with the technical names, especially those employed in classification, in Natural History, and Geology, to the students of which it will prove, it is to be hoped, a very great boon.]

### PHYSICS.

*Professor, WILLIAM BARKER, M.D.*

OBJECTS OF PHYSICAL SCIENCE.—Definition of forces acting on Matter. Molecular and Physical forces—Matter, ponderable and imponderable.

### PROPERTIES OF PONDERABLE MATTER.

PHYSICS OF PONDERABLE MATTER.—General properties of Matter—Form—Extension—Aggregation—Divisibility—Mathematical proof of Infinite Divisibility—Practical limits—Illustrations of extreme Divisibility afforded by Chemistry and by Mechanical and other means—Impenetrability—Porosity—Elasticity—Relative Elasticity of different forms of Matter—Tenacity—Measures of Cohesive Force—Importance of knowledge of force of Cohesive Attraction in the Arts—Adhesion—Capillary Attraction—Endosmose and Exosmose—Gravity—Its action on Matter of all Forms—Specific Gravity—Inertia—Laws of Inertia.

### STATICS.

FORCES EXERTED ON MATTER.—Force produces rest or motion or change of direction, on Matter in motion—Limit of force—Measurable and Immeasurable forces—Measurable forces, how expressed in quantity and direction—Composition and Resolution of Forces—

Resultant of two or more forces—How expressed in quantity and direction—Parallelogram of forces—Polygon of forces—Parallel forces—Centre of Gravity—determination of its position in lines, symmetrical figures, surfaces and solids—Equilibrium—Stable or unstable.

### DYNAMICS.

**THEORY OF MACHINERY.**—Motive powers used in Machinery, or Prime Movers—Primary sources of Motive Power—Machines do not increase power, merely alter time or direction of its application.

**SIMPLE MACHINES.**—Lever, three species of—Conditions of Equilibrium in three species—Inclined Plane—Pulley—Balance—Wheel and Axle—Wheelwork—Screw—Hunter's Screw—Wedge—Pulleys—Compound Pulleys—Angular divergence of Cords.

**FRICITION AND RIGIDITY.**—Different kinds of friction—Laws of friction—Friction in Lever—Inclined Plane and Wedge—Pivot friction—Friction of rolling bodies—Rigidity of Ropes and Chains.

**STRENGTH OF MATERIALS.**—Dependent on forces resisting tension, pressure, or torsion—How ascertained by direct experiment—Relative strength of Solids of different species—Relative strength of different forms of same material.

**FORCES OF MATTER IN MOTION.**—Composition and Resolution of Motion—Motion absolute or relative—Resultant of two or more Motions—Curvilinear Motion—Momentum—Forces derived from Momentum—Formulae expressive of Momentum—Application to Machinery—Laws of Action and Reaction—Effects of Collision—Effects on elastic and inelastic Matter—Centrifugal force—Consequence of Inertia—Whirling Table—Application of Centrifugal force to manufactures.

Effects of Gravity in producing Motion—Motion, uniform or accelerated—Accelerated velocity—Attwood's Machine for proving laws of accelerated motion—Formulae for expressing relations of Space, Time, and Velocity—Motion of bodies down an Inclined Plane—Pendulum—Compensating Pendulum.

### HYDROSTATICS AND HYDRODYNAMICS.

**PROPERTIES OF LIQUIDS.**—Elasticity of Liquids—Compressibility of Water—Cersted's Experiments—Liquid Pressure—Pressure of Liquids in every direction—Hydrostatic Paradox—Bramah's Press—Application to raising Weights or to Compression—Pressure of Water at various depths.

**UPWARD AND LATERAL PRESSURE.**—Pressure as depth—Pressure on sides of Vessels—Examples of Pressure—Practical applications

—Effects of immersion of Solids in Liquids—Specific Gravity of Solids, how ascertained—Specific gravity of Liquids and Gases.

**MOTION OF LIQUIDS.**—Liquids obey laws of Inertia—Momentum of Liquids in Motion—Velocity of Efflux—Application to produce Motion in Machinery—Water Engines—Water Wheels—Reaction Wheels—Machines for raising Water—Centrifugal Pumps—Archimedes' Screw.

### PNEUMATICS.

**APPARATUS USED IN RESEARCHES ON PROPERTIES OF AIR.**—Air-pumps—Syringe—Condenser—Application of pressure of Air in Arts—Undulation produced in Liquids.

**GENERAL PROPERTIES OF GASES.**—Elasticity—Density—Mariotte's Law—Weight—Atmospheric Pressure—Barometer, various forms of—Height of Atmosphere—Atmospheric Waves—Diurnal variation of Barometer—Method of measuring heights of Mountains by Barometer—Barometer employed as indicator of Weather—Fallacy of popular ideas of its utility.

**PNEUMATIC MACHINES.**—Lift Pump—Force Pump—Fire Engine—Hero's Engine—Atmospheric Engine.

### ACOUSTICS.

**SOUND.**—Its Propagation—Intensity of Sound—Velocity in Gases, Liquids, and Solids—Reflexion and Refraction of Sound—Echo and Resonance.

### VIBRATION OF CORDS.

### VIBRATION OF AIR IN PIPES.

### VIBRATION OF RODS AND PLATES.

### THEORY OF MUSIC.

### HEAT.

**HEAT.**—Theories of—Sources of Heat—Effects on Matter—Importance of knowledge of its effects in the Arts.

**EXPANSION BY HEAT OF SOLIDS, LIQUIDS, GASES.**—Coefficient of expansion—Force of dilatation in Solids—Importance of knowledge of laws of dilatation of Solids in Arts of Construction—Relative dilatation of different classes of Solids—Application to construction of Standards of Length—Pendulums. Measures of Heat.

**THERMOMETERS.**—Principle of Thermometer—Liquids employed in its Construction—Mode of Graduation—Scale adopted in different Countries—Fahrenheit—Reaumur—Centigrade—Sources of Error in use of Thermometers—Bregnet's Thermometer—Pyrometers,—Wedgwood's—Daniel's—Exceptions to Law of Dilatation—Apparent exceptions.

**LATENT HEAT.**—Absorption of Heat by solution—Evolution by crystallization—Congelation—Latent Heat of Vapours—Ebullition—Elastic Force of Vapours—Application of these Laws to the principles of the Steam Engine.

**EARLY HISTORY OF STEAM ENGINE.**—First Engine devised by Hero of Alexandria—Inventions of Garay—De Cans—Branca—Marquess of Worcester—Morland—Papin—Savary—Newcomen—Watt.

**PARTS OF ENGINE.**—Boiler—Gauges—Feeding Apparatus—Cylinder—Piston—Crank—Valves—Spindle Valve—D Valve—Sliding Valve—Fourway Cock—Fly Wheel—Governor.

**RADIATION AND REFLECTION OF HEAT.**—Laws of Radiation—Causes modifying Radiation—Reflection of Heat from plane surfaces—Reflection from curved surfaces—Apparent reflection of Cold—Reflective power of different surfaces.

**DIATHERMANY.**—Diathermal properties of different substances—Experiments of Melloni—Theory respecting the different species of calorific rays.

## ELECTRICITY.

**ELECTRICITY.**—Its relation to other Physical Forces. Its Species, Statical and Dynamical Electricity—Sources of Statical Electricity—Conductors and Non-Conductors—Instruments for testing presence of Free Electricity—Electrosopes and Electrometers—Condensers—Laws of Electric Induction—Lines of Force—Theory of Electrical Machine—Leyden Jar—Laws of Electrical Charge—Tension, Intensity, and Quantity—Electrophorus—Different forms of Electrical Discharge—Length of Spark—Influence of Points—Discharge by Conduction—Discharge through Non-Conductors.

**MECHANICAL AND CHEMICAL AGENCY OF STATIC ELECTRICITY.**—Luminous effects—Magnetic effects—Mechanical Disruption—Chemical decomposition produced by it—Meteors—Lightning and Thunder—Whirlwinds—Waterspouts—Aurora Borealis.

**DYNAMICAL ELECTRICITY.**—Discovery by Galvani and Volta—Theory of Voltaic Pile—Various form of Voltaic Battery—Electrolytic Force—Application in Arts and Manufactures.

MAGNETISM.—General Phenomena—Methods of Communicating Magnetism—Magnetic Induction—Substances capable of Magnetic Induction—Effects of Heat on Magnetism.

TERRESTRIAL MAGNETISM.—Mariner's Compass—Declination—Magnetic Meridians—Diurnal Variation—Periodical Variation.

ELECTRO-MAGNETISM.—Laws of Electro-Magnetic Induction—Rotation of Currents—Magneto-Electricity—Practical Applications.

MOTIVE POWER AFFORDED BY ELECTRO-MAGNETISM.—Electricity applied to Telegraphic Purposes—Velocity of Transmission of Electric Currents—Electric Telegraph, its early History—Statical Electricity first employed—Objections to its use—Electro-Magnetic Force—Its Applications—Chemical Decomposition—Various Forms of Printing Telegraph—Regulation of Time by Electric Telegraph—Electric Clocks—Applications in Arts and Manufactures.

### OPTICS.

LIGHT.—Laws of Propagation—Velocity—Theories respecting its Cause—Refraction of Light—Snellius' Law of Sines—Lenses—Formation of Images by Lenses—Dispersion of Light—Reflection of Light—Reflection from Plain Surfaces—Reflection from Curved Surfaces—Images formed by Reflection—Laws of Vision—Structure of the Eye—Optical Instruments—Reflecting and Refracting Telescopes—Microscopes—Camera—Polarization of Light.

### CHEMISTRY.

*Professor, WILLIAM K. SULLIVAN, PH.D.*

### PRELIMINARY ELEMENTARY NOTIONS.

Distinction between the phenomena which appertain to the division of Science denominated Physics or Natural Philosophy, and those whose study constitutes the branch of Science called Chemistry.

Division of bodies into Simple and Compound—Divisibility of Matter—Different physical conditions which matter can assume—Cohesive Force—Chemical Force—Physical properties which Chemists employ to specify bodies—Specific Gravity, and the methods employed to determine it.

Simple bodies actually known.

Chemical Nomenclature—Notation, and Formulae.

Classification of the Simple bodies into two groups, *Metalloids* and *Metals*.

## METALLOIDS.

Physical and Chemical properties of  $\alpha$  and  $\beta$  Oxygen, Hydrogen, and Nitrogen.

Combinations of Oxygen and Hydrogen—Water.

Combinations of Nitrogen and Oxygen—Atmospheric Air—Combinations of Nitrogen and Hydrogen—Ammonia.

Physical and Chemical properties of Sulphur, Selenium, Tellurium, Fluorine, Chlorine, Bromine, Iodine, Phosphorus, Arsenic, Boron, Silicon, Carbon, and their most important compounds with one another, and with the other Metalloids.

**SUMMARY.**—Numerical laws which govern the combinations by Weight of the Metalloids with one another. Establishment of the equivalents of the Metalloids from their combinations. Laws of Gaseous combinations.

## METALS.

*Characteristic Physical Properties of the Metals.*—Combinations of the Metals with one another—Alloys.

### CHEMICAL PROPERTIES OF METALS.

*Action of Oxygen upon Metals.*—Properties of Metallic Oxides—Action of Light upon Metallic Oxides—Action of the several Metalloids upon them—Preparation of Metallic Oxides—Classification of Oxides.

*Action of Sulphur upon Metals.*—Properties of Sulphides—Action of Heat upon Metallic Sulphides—Action of the several Metalloids—Preparation of Metallic Sulphides—Classification of Sulphides—Compounds of Selenium and Tellurium.

*Action of Chlorine upon Metals.*—Properties of Chlorides—Action of Light and Heat upon Metallic Chlorides—Action of the several Metalloids upon them—Action of Metals—Action of Compound bodies—Preparation of Metallic Chlorides—Classification of Chlorides.

Bromides—Iodides—Fluorides.

*Action of Phosphorus, Arsenic, and Nitrogen, upon Metals;* and character of the resulting compounds.

*Action of Boron, Silicon, and Carbon upon Metals;* and character of the resulting compounds.

### CLASSIFICATION OF METALS.

Principles upon which the classification of Metals is founded—Convenient division of Metals into six classes, founded upon the relative facility with which they decompose water.

*First Class*—Potassium, Sodium, Lithium, Barium, Strontium, Calcium, Magnesium.

*Second Class*—Glucinum, Thorium, Yttrium, Zirconium, Lanthanum, Cerium, Manganese.

*Third Class*—Zinc, Cadmium, Nickel, Cobalt, Iron, Chromium, Aluminum, Tin.

*Fourth Class*—Vanadium, Tungsten, Molybdenum, Osmium, Tantalum, Titanium, Antimony, Uranium.

*Fifth Class*—Copper, Lead, Bismuth.

*Sixth Class*—Silver, Mercury, Gold, Palladium, Platinum, Rhodium, Iridium.

### SALTS.

Definition of the term Salt—Different kind of Salts—Amphigenic Salts—Halogenic Salts—Division of Salts into *Neutral Acid* and *Basic*—Relation between the Oxygen contained in the Acid and base of each of these kinds of Salts—Difference between Mono-basic and Polybasic Acids—Hydrates—Water of Crystallization of Salts.

### Laws of Solubility of Salts.

Action of Acids upon bases and upon Salts—Action of bases upon Salts—Mutual action of Salts upon one another.

Characters of the Salts formed by the union of the acids, produced by the combination of two Metalloids, and Metallic bases—Sulphates, Sulphites—Hypsulphites, &c.—Seleniates and Selenites—Chlorates, Perchlorates, Hypochlorites—Bromates—Iodates—Periodates—Phosphates, Phosphites—Arseniates, Arsenites—Nitrates, Nitrites—Borates—Silicates—Carbonates.

Properties of the Metals of the first class, and of their most important compounds. Distinctive characteristics of the Salts of the different Metals of the first class.

Distinctive characteristics of the Salts of the different Metals of the second, third, fourth, fifth, and sixth classes.

## PHYSICAL CHEMISTRY.

### ELEMENTARY PRINCIPLES OF CRYSTALLOGRAPHY.

**THERMO-CHEMISTRY.**—Dilatation of Solids, Liquids, and Gases—Density of Solids and Liquids—Density of Water at different Temperatures—Maximum Density of Saline Solutions—Use of the Areometer—Fusion—Solidification—Latent Heat—Evaporation—Elastic force of Gases and Vapours—Distillation and Sublimation—Density of Gases and Vapours—Specific Heat—Heat developed by Combination—Thermo-Chemical Laws—Calorimetry—Different Methods employed to determine the Specific Heat of Bodies, and the Heat Developed by Combination—Nature of Flame—Theories of Combustion—Chemical Relations of Radiant Heat.

**CHEMICAL RELATIONS OF LIGHT.**—Combinations effected by the Aid of Light. Decompositions produced under the Action of Light. Molecular Changes induced in Bodies by the Action of light, by which their Chemical Properties are Altered—Different Effects of the Different Coloured Rays of the Solar Spectrum. Influence ex-

erted by various Chemical Substances upon the character and position of Franenhofer's lines and upon the Refrangibility of Light—Epipolic Dispersion of Mr. Stokes. Action of various Bodies upon Polarized Light. Phenomena of Colour in Plates of Quartz cut Perpendicularly to the Axis of the Crystal—Inverted Quartz. Rotatory or Circular Polarization of Liquids and Gases—Theory of Fresnel, Biot's Apparatus for Circular Polarization. M. Pasteur's Experiments on the Corelation between the Crystallographic Form, and the Optical Properties.

ELECTRO-CHEMISTRY.—Electro-Chemical Theories—Classification of bodies founded upon their Electrical Relations—Laws of Electrolysis.

MOLECULAR ACTIONS.—General considerations upon the nature of Chemical Affinity—Influence of Cohesion and Elasticity upon Chemical Affinity—Relation between Affinity and Cohesion—Molecular Structure of Bodies—Tempering and Annealing—Phenomena of Crystallization—Changes of Form in Crystals—Solidification under Pressure—Changes in Affinity, and Solubility by Heat and Pressure—Changes effected by repeated Fusions—Properties of Precipitates—Relative Compressibility of different Liquids—Changes in Elasticity from Vibration—Passage of Electric Currents, &c.—Molecular Changes effected by unequal Pressure in Elastic Bodies—Relation between Specific Gravity and Chemical Composition—Capillarity—Adhesion of Liquids and Solids—Capillary Affinity—Osmotic Force.

MOLECULAR CONSTITUTION OF BODIES.—Atomic Theory—Atomic Volume—Isomorphism, Dimorphism, and Paramorphism—Polymeric Isomorphism—Allotropism—Passivity—Isomerism.

STOEHIOOMETRY.—Laws of Combination—Volume Theory—Establishment of Chemical Formulae.

### ORGANIC CHEMISTRY.

Definition of an Organic Body—Distinction made by Chemists between Organic and Organized Substances—Elementary Composition of Organic Bodies—Proximate Analysis of Animals and Plants—Chemical Formulae.

CONSTITUTION AND CLASSIFICATION OF ORGANIC SUBSTANCES.—Theory of Compound Organic Radicals—Theory of Types, and Doctrine of Substitution—Homologous Series of Organic Compounds.

### CHEMICAL CONSTITUTION OF THE CHIEF ORGANIC TYPES.

DECOMPOSITION OF ORGANIC BODIES, AND NATURE OF THE RESULTING PRODUCTS.—Action of Oxygen and of Oxidizing Agents—Decay—Putrefaction—Fermentation—Action of Heat—Destructive Distillation—Combustion—Action of Sulphuric Acid—Chlorine—Bromine—Fixed Alkalies—Ammonia—Sulphuretted Hydrogen, &c.

## PHYSIOLOGICAL CHEMISTRY.

PROXIMATE PRINCIPLES OF VEGETABLES.—Amylaceous and Saccharine Bodies—Pectin Bodies—Vegetable Acids—Fats and Oils—Waxes—Essential Oils—Camphors and Resins—Colouring Matters—Indifferent Bodies—Alkaloids, and other Nitrogenized Constituents of Plants.

PRINCIPAL SOLID SUBSTANCES CONSTITUTING ANIMALS—Bones—Teeth—Cartilage—Horny Matter—Hair—Bristles—Feathers—Shells—Skin—Membranes—Muscular Flesh—Albuminous Bodies—Creatine—Gelatinous Bodies—Animal Fats—Cerebral and Nervous Matter.

PRINCIPAL FLUIDS OF THE ANIMAL BODY.—Blood—Lymph—Saliva—Gastric and Pancreatic Juices—Intestinal Fluid—Bile—Chyle—Milk.

### EXCREMENTITIOUS MATTER OF ANIMALS.

CHEMICAL CHANGES WHICH TAKE PLACE DURING THE GROWTH OF VEGETABLES.

CHEMICAL CHANGES WHICH TAKE PLACE IN THE ANIMAL ECONOMY.

## NATURAL HISTORY.

*Professor (Acting), J. R. KINAHAN, M.B.*

Natural History, the science which treats of organized beings: its two branches. Zoology, or the Science of Animal Life; Botany, or the science of Plant Life. Distinctions between Plants and Animals—Sensation; Contractility; Assimilation of Nutrition; Power of Motion; Circulation. Analogies between Plants and Animals. Cellular Plants; Cellular Animals.

## ZOOLOGY.

### STRUCTURAL AND PHYSIOLOGICAL.

Various systems of which animal bodies are composed, more especially those of industrial or scientific import. Tegumentary System—General Integument, Hair, Bristles, Wool, Spines, Horns, Solid Horns, Hollow Horns, Deciduous Horns, Whalebone, Horny Integuments. Teeth—Composition of Teeth, Mode of Growth of Teeth, Scales. Muscular System. Osseous System—Skeleton, Exoskeleton, Endoskeleton. Circulating System,—Heart, Veins, Arteries, Lungs, Gills, methods of Respiration. Nervous System—Nervous Centres or Ganglia, Nervous connecting Filaments or Nerves.

Connexion between the study of Zoology and Palaeontology.

## BOTANY.

## STRUCTURAL AND PHYSIOLOGICAL.

Organology, science of Organs. Simple organs—the Cell and Vessel. Compound organs—Root, Stem, Leaf, Seed. Tissues—Homogeneous Tissue, Complex Tissue, Cellular Tissues, Vascular Tissue. Parenchyma, Pleurencyma, Prosenchyma Bothrenchyma, Woody Fibre. Theories of Cell growth, Cell propagation, Cylogenesis—Fissure, Gemmation, Conjugation. Free Cellular, Kinds of Cells, forms of Cells, Intercellular spaces, Circulation in Cells. Laticiferous Tissue, Cyclosis. Contents of Cells and Vessels—Starch, Raphides, &c.

Organs of Nutrition. Of Reproduction. Histological division of Plants, or that founded on Tissues—Cellulares, Vasculares, Thallophytes, Cormophytes. Cellular plant life, in both Cellulares and Vasculares—The Axis—descending, ascending. Root—Primary Roots—Annual, Biennial, Perennial; Secondary Roots. Aerial Roots, Epiphytic, Parasitic Roots. Mode of growth and office. Spongiola, Fibrillæ. Forms and kinds of Roots.

Stem; Difference between Stem and Root; Growth, and external modifications of. Nodes, Internodes, Branches or secondary Axes, Buds undeveloped branches. Adventitious, Accessory, Buds, Stolons, Runners, Tendrils, Thorns, &c. Rhizome, Tuber, Bulb, Corm.

Internal structure of stem of Cotyledones.

Divisions of Stems; Difference between Stem and Caudex. Endogenous Stem, mode of growth. Exogenous Stem, mode of growth, first year growth, Pith, Medullary Sheath, Wood, Medullary Rays, Bark—Exophlaeum, Epidermis, Mesophlaeum or Liber Endophlaeum. Cambium. Annual increase in Rings. Leaf, Arrangement and development of. Phyllotaxis, or distribution. Law of *Alternans*. Compound and Simple leaves. Partite and Multifid leaves. Petiole, Stipule, Lamina. Defective leaves—Sessile, Extipulate, Phyllocladia, Phyllodia, Acicilar, Ascidia. Internal structure of leaf—Epidermis, Stomates, Hairs. Defoliation or fall of leaf, causes assigned—Deciduous, Annual, Persistent leaves. Duration of leaf varying much. Flower made up of modified leaves. The production of Flowers, main object of Vegetable life; they obey law of *Alternans* as well individually as in their parts. Inflorescence, or assemblage of Flowers, Indefinite Inflorescence, Definite Inflorescence, forms of. Development of Heat by Flowers. Exhaustion and season of rest in Plants.

Floral Organs; the origin of the Leaf and Flower the same. Floral Envelopes—Essential—Andræcium or Staminal Whorl, Gynæcium, or Pistil. Non-essential—Calycine Whorl, or Calyx. Corolline Whorl, or Corolla. Sepals. Petals. Perianth or Perigone. Bracts. Stamens, Filaments and Anther. Pollen. Pistil. Ovary, Style, Stigma, Carpel. Perianth, modified by suppression of parts; Choris and Conjugation; Early development and fertilization of Ovule. Diclinous, Monoclinous Flowers. Monæcious, Diæcious, Her-maphrodite plants. Formation and structure of Fruit—Endocarp,

Exocarp, Mesocarp, Arrillus, Arillode, Seed. Naked Seeds, Angiosperms, Gymnosperms. Cotyledon, Plumule, Radicle, Caulicle. Germination of Monocotyledons, Dicotyledons, Polycotyledons. Acotyledonous Exogens. Spore, Sori, Sporidia. Caudex, Frond. Thallus. Pistillidia, Antheridia. Acrogens, or Summit Growers, link between Cellular and Vascular Plants, contain many extinct species. Anogens. Thallogens, Methods of reproduction. Large and small Spore, Prothallus, Innovation, Gemmation, Free Cell formation. Alternation of generation.

Physiology of Vegetation. Influence of Light, Heat, Air, on Vegetable life. Plant respiration. Food of plants. Elementary composition. Laws of Distribution of plants—The whole plant organs referable to a general type General Laws of species, variety, Hybrids, &c. Law of progressive development unfounded in fact.

## ZOOLOGY.

### SYSTEMATIC.

General principles of Zoological Classifications proposed by Aristotle, Linnæus, Ray, Hunter, Cuvier, and Owen. Characters of the great classes—Vertebrata, Mollusca, Articulata, Nematoneura, and Acrita or Protozoa, of which the last two correspond to Cuvier's Radiata.

### VERTEBRATA.

Nervous centres enclosed in brain case and back bone.

#### I. MAMMALIA,

Viviparous. Warm blooded :

1. Bimana. (Man.)
2. Quadruped. (Monkeys, &c.)
3. Cheiroptera. (Bats.)
4. Insectivora. (Hedgehog, Mole, &c.)
5. Carnivora. (Bear, Cat, Dog, Stoat, Seal, &c.)
6. Rodentia. (Rat, Hare, &c.)
7. Edentata. (Shrew, Anteater, Sloth, &c.)
8. Pachydermata. (Elephant, Hog, Horse, Dugong, (?) &c.)
9. Ruminantia. (Stag, Giraffe, Cow, Camel, &c.)
10. Cetacea. (Whale, Porpoise, &c.)
11. Marsupiata. (Opossum, Kangaroo, &c.)
12. Monotremata. (Platypus, Echidna.)

#### II. AVES OR BIRDS,

Oviparous. Warm blooded :

1. Raptore. (Hawk, Vulture, Owl.)
2. Incessores. (Crow, Parrot, Swallow.)
3. Rasores. (Grouse, Pigeon, &c.)
4. Grallatores. (Crane, Heron, Plover, &c.)
5. Natatores. (Duck, Albatross, Gull, &c.)

## III. REPTILIA.

Cold blood, skin covered with scales or plates, oviparous or ovo-viviparous, breathe by lungs.

1. Testudinata. (Tortoise, &c.)
2. Enaliosauria. (Ichthyosaurus, &c.)  
*(extinct.)*
3. Loricata. (Crocodile, Alligator.)
4. Squamata. (Lizard, Slow Worm, Serpent.)

## IV. BATRACHIA.

Cold blood, naked skin, oviparous, undergo metamorphosis, for the most part breathe by lungs or branchiæ.

1. Anoura. (Frog, Toad.)  
*metamorphosis.*
2. Urodea. (Newt, Salamander, &c.)  
*metamorphosis.*
3. Amphineusta. (Proteus, Siren, &c.)  
*metamorphosis.*
4. Abranchia. (Menopoma, Amphiuina, &c.)  
*no metamorphosis (?) or branchiæ.*
5. Apoda. (Cecilia, &c.)  
*no metamorphosis (?) or branchiæ.*

## V. PISCES or FISH.

Cold blood, oviparous, breathe by branchiæ.

*Cuvier's Classification.*

Osseous.	<ol style="list-style-type: none"> <li>1. Pectinobranchii.           <table border="0"> <tr> <td style="vertical-align: top; padding-right: 10px;"><i>a</i></td> <td>acanthopterygii. (Perch, Bream.)</td> </tr> <tr> <td style="vertical-align: top; padding-right: 10px;"><i>b</i></td> <td>malacopterygii. (Salmon, Sole.)</td> </tr> <tr> <td style="vertical-align: top; padding-right: 10px;"><i>c</i></td> <td>apodes. (Muræna.)</td> </tr> </table> </li> <li>2. Plectognathi. (Globe-fish.)</li> <li>3. Lophobranchii. Pipe-fish.)</li> </ol>	<i>a</i>	acanthopterygii. (Perch, Bream.)	<i>b</i>	malacopterygii. (Salmon, Sole.)	<i>c</i>	apodes. (Muræna.)
<i>a</i>	acanthopterygii. (Perch, Bream.)						
<i>b</i>	malacopterygii. (Salmon, Sole.)						
<i>c</i>	apodes. (Muræna.)						
Chondropterygii, or Cartilaginous.	<ol style="list-style-type: none"> <li>4. Eleutheropomi. (Sturgeons, &amp;c.)</li> <li>5. Plagiostomi. (Shark, Ray, &amp;c.)</li> <li>6. Cyclostomi. (Lampreys, &amp;c.)</li> </ol>						

*Muller and Owen's Classification.*

1. Dermopteri. (Lancelet, Myxine, Lamprey.)
2. Malacopteri. (Eel, Herring, Pike.)
3. Pharyngognathi. (Saury-pike, Wrasse.)
4. Anacanthini. (Ophidium, Cod, Plaice.)
5. Acanthopteri. (Gurnard, Mackerel.)
6. Plectognathi. (File-fish, Globe-fish.)
7. Lophobranchii. (Pipe-fish, Sea-horse.)
8. Ganoidei. (Lepidostens, Cephalaspis, Sturgeon.)
9. *Protopteri*, by some referred to reptiles. (Lepidosiren.)
10. Holocephali. (Chimæra.)
11. Plagiostomi. (Shark, &c.)

Order 9 now placed among reptiles.

*Agassiz's Classification.*

1. Ganoideans. (Lepidocephalichthyes, Sturgeon.)
2. Placoideans. (Sharks, Rays.)
3. Ctenoideans. (Perch, &c.)
4. Cycloideans. (Carp, Herring, Salmon.)

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MOLLUSCA.

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Nervous centres scattered unsymmetrical : bodies soft.

## I. CEPHALOPODA.

Bodies symmetrical, head distinct, arms around head, respiration by branchiae.

1. Dibranchiata.  
branchiae 2.  
a decapoda. (Squid, Belemnite.)  
b octopoda. (Argonaut, Poulpe.)
2. Tetrabranchiatae.  
branchiae 4. (Nautilus, Ammonite.)

## II. CEPHALAPHORA.

Bodies unsymmetrical, head distinct, respiration various, some species undergoing metamorphosis.

1. Gasteropoda.  
*foot a broad fleshy disk.*  
a opisthobranchiata. (Doris, Aplysia, Bulla.)  
*branchial respiration.*  
b pulmonifera. (Snail, Slug, &c.)  
*pulmonary cavity.*  
c prosobranchiata. (Chiton, Whelk, Periwinkle.) *branchial respiration.*
2. Heteropoda.  
*foot a vertical plate, (Carinaria, Firola.)*
3. Pteropoda.  
*fins each side of head, (Clio borealis.)*

## III. ACEPHALA.

Bodies unsymmetrical, no head.

1. Lamellibranchiata. (Oyster, Mussel, Solen.)
2. Palliobranchiata or Brachiopoda. (Terebratula, Lingula.)
3. Tunicata.  
*no external shell.*  
(Botryllus, Ascidia.)

## IV. POLYZOA (Bryozoa, Crisis, &amp;c.)

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ARTICULATA.

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Nervous centres in pairs symmetrically arranged in parallel lines.

## I. CRUSTACEA.

Body articulated, first seven joints of thorax consolidated, articulated limbs, branchial respiration, undergo metamorphosis.

Malacostrace.

1. Podophthalmia, eyes on footstalks.  
*a* decapoda.
  1. brachyura. (Crabs, &c.)
  2. anomoura. (Hermit Crabs.)
  3. macrura. (Lobster.)
  - b* stomapoda. (Squills, &c.)
2. Edriophthalmia. Sessile eyes.  
*a* amphipoda. (Gammarus.)  
*b* laemipoda. (Cyamus.)  
*c* isopoda. (Wood-louse.)
3. Branchiopoda.  
*a* cladocera. (Daphnia.)  
*b* phyllopoda. (Limnadia, &c.)  
*c* trilobites. (Calymene, &c.)  
(*extinct.*)
4. Lophyropoda.  
*a* copepoda. (Cyclops.)  
*b* ostracoda. (Cypris, Cythere, &c.)
5. Pæcillopoda. (Limulus or King Crab, Eurypterus, &c.)
6. Siphonostomata. (Caligus, Lernæa.)
7. Cirripedia. (Barnacles, &c.)

## II. MYRIAPODA.

Body articulated, joints all distinct, numerous articulated limbs, undergo partial metamorphosis, respiration tracheal.  
(Scolopendra, Julius, &c.)

## III. ARACHNIDA.

Eight articulated imperfect limbs, cephalo thorax, and abdomen, metamorphosis.

### 1. Pulmonaria.

*pulmonary cavity.*  
(House Spider, Mygale, Scorpion.)

### 2. Trachearia.

*tracheal respiration.*  
(Chelifer, Acarus.)

## IV. INSECTA.

Legs six, head, thorax, and abdomen distinct, respiration tracheal, metamorphosis.

### 1. Thysanura. (Podura, Lepisma.)

### 2. Parasita. (Pediculus, &c.)

### 3. Suctoria. (Flea, &c.)

### 4. Coleoptera (Beetle, &c.)

### 5. Orthoptera. (Earwig, Cricket, Locust.)

### 6. Hemiptera. (Bug, Cicada, Aphis.)

### 7. Neuroptera. (Dragon-fly, White ant.)

### 8. Hymenoptera. (Saw-fly, Ichneumon, Ant.)

### 9. Lepidoptera. (Butterflies, Moths, &c.)

### 10. Rhipiptera. (Stylops.)

### 11. Diptera. (House-fly, Oestrus.)

## V. ANNELLIDA.

Body soft in rings, no limbs, respiration internal by pulmonary cavity, or external by branchiæ. Metamorphosis.

## 1. Abranchia.

*pulmonary cavity.* (Leech, Earthworm.)

## 2. Dorsibranchia.

*branchiæ attached to each segment.* (Lugworm, &c.)

## 3. Tubicola.

*branchiæ attached to anterior segment.* (Gold comb, &c.)

## NEMATONEURA.

Nervous centres as filaments.

## I. ECHINODERMATA.

1. Crinoidea. (Stone lilies, Comatula, &c.)

2. Cystoidea. (Cystidae.)

*(extinct.)*

3. Blastoidea. (Pentremites, &c.)

*(extinct.)*

4. Ophiuridæ. (Sandstar, &c.)

5. Asteroidea. (Sunstar, &c.)

6. Perischoechinoidea. (Palæchinus, &c.)

*(extinct.)*

7. Echinoidea (Sea urchins.)

8. Holothuriadæ. (Sea cucumbers.)

## II. CÆLELMINTHA. (Ascaris, Lumbricus.)

## IV. ROTIFERA. (Wheel animalcules.)

Sub Class, III. EPIZOA, now placed among Crustacea.

Sub Class, IV. among Mollusca.

## PROTOZOA or ACRITA.

No nervous centres or filaments as yet detected ; must be looked on as a transitional division.

## I. ENTOZOA. (Distoma, Cercaria.)

## II. HYDROZOA. (Hydra, &amp;c.)

## III. PHYTOZOA or ANTHOZOA. (Corals, Sea Anemone, &amp;c.)

## IV. OOZOA or PROTOZOA. (Sponges, &amp;c.)

Remarks on preceding classes ; objections to them. Class Vermes of modern authors contains :—

## I.—ROTIFERA. (Wheel Animalcules.)

## II.—ANNELLIDA. (Earthworm.)

## III.—CÆLELMINTHA. (Ascaris, &amp;c.)

## IV.—ENTOZOA. (Distoma, &amp;c.)

## BOTANY.

## SYSTEMATIC.

Artificial or sexual system of Linnæus. Natural Systems, of Ray, Decandolle, Jussieu. Comparative value of Organs in Taxology. No such thing as a perfect linear system. Imperfection of all systems, most probably dependant on the extinction of connecting genera.

## THALLOGENS.

Cellular Plants. Thallus and Spores.

## I. ALGÆ.

Submersed Plants, germinating bodies in non-spiral cells.

## 1. Diatomaceæ.

Plant unicellular, reproduction by fissure and conjugation.

## a. Diatomææ.

Silicious covering. (Cymbella, &c.)

## b. Desmidææ.

no silicious covering. (Euastrum.)

## 2. Chlorospermeæ, green colored Seaweeds.

Many unicellular, reproduction by conjugation, Zoospores.

(Laver Red snow plant.)

## 3. Rhodospermeæ, rose colored Seaweeds.

Fructification of two kinds, tetraspores. (Carrigeen, Coralline.)

## 4. Fucaceæ, brown colored Seaweeds.

Multicellular, expansion thalloid or filamentous.

Fructification, with two kinds of cells. (Laminaria, Gulfweed.)

## II.—FUNGL.

Under ground filamentous thallus, called mycelium, spores naked or enclosed in thecæ. (Toadstools, Mushroom.)

## III.—LICHENES.

Thallus foliaceous, crustaceous, or leprous; conceptacles superficial or enclosed. (Cudbear, &c.)

## IV.—CHARACEÆ.

Thallus parallel cellular tubes, with whorled branches, organs of fructification of two kinds. (Chara, Nitella.)

## ANOGENS.

## I.—HEPATICÆ, or Liverworts.

Cellular leaf-like expansion, and axis, reproduction by spores and buds.

## 1. Ricciaceæ.

No elaters or valves to sporangia. (Riccia.)

2. *Marchantiaceæ.*

Elaters, sporangia bursting irregularly, reproduction also by buds.

(*Lunularia*, &c.)

3. *Jungermanniaceæ* or *Scalemosses.*

sporangia, four-valved, furnished with elaters.  
(*Scalemosses.*)

## II. MUSCI OR MOSES.

Cellular axis with distinct leaf-like expansions, reproduction through spore, innovation also met with.

1. *Bryaceæ.*

Sporangia not opening by valves.

(*Urnmosses*, &c.)

2. *Andræaceæ.*

Sporangia cleft into four longitudinal valves.  
(*Split mosses.*)

## ACROGENS.

Vascular plants, caudex, fronds, spores, summit growers.

## I. LYCOPODIACEÆ.

Caudex creeping, branched, fronds minute, fructification axillary. (*Wolfsfoot, Club moss.*)

## II. MARSILEACEÆ OR PEPPERWORTS.

Caudex creeping, vernation circinate, fructification of two kinds, at bases of fronds. (*Quill wort, &c.*)

## III. EQUISETACEÆ.

Caudex subterranean, creeping; branches hollow, fronds as membranous scales, fructification at termination of branches. (*Horse tails.*)

(Many extinct fossil genera probably referable to this division.)

## IV. FILICES OR FERNS.

Caudex stem like, spores for most part on modified fronds; plants pass through a prothalloid stage distinct from parent.

1. *Danæaceæ.*

Sporangia dorsal, exannulate, splitting irregularly.  
(*Danæa*, &c.)

2. *Polypodiaceæ.*

Sporangia annulate, dorsal or marginal, vernation circinate. (*Spleenwort, Brakes, Trichomanes.*)

3. *Osmundaceæ.*

Sporangia on transformed frond, imperfectly annulate, vernation circinate.  
(*Royal fern, &c.*)

## 4. Ophioglossaceæ.

Sporangia on special branch of frond, exannulate, vernation straight. (Adderstongue, Moonwort.)

Remarks on preceding divisions.

The classes Thallogens, Anogens, Acrogens, comprised under Cryptogamia Linnæus, Acotyledones of other Authors. Thallogens and Anogens constitute Cellulares of Authors.

## ENDOGENS.

Vascular plants, furnished with seed, leaves, stem, root; one seed-lobe to embryo, veins of leaves generally in parallel arrangement, growth of stem endogenous.

## I. GLUMIFERÆ,

Flowers glumaceous. (Sedge, Grass, &c.)

## II. PETALOIDEÆ, or FLORIDEÆ,

Flowers perianth.

1. Epigynæ. (Banana, Orchis, &c.)

2. Hypogynæ. (Palms, Lilies, &c.)

3. Incompletae. (Screw-pine, Cuckoo pint, &c.)

## III. DICTYOGENÆ.

Venation of leaves reticulated.

(Yam, Smilax.)

## EXOGENS.

Vascular plants, furnished with seed, leaves, stem (made up of wood and bark,) and root; seed lobes either two, many, or none; veins of leaves reticulated, growth of stem exogenous.

## I. APETALÆ.

## 1. Gymnosperms.

Embryo polycotyledonous, seeds naked.

*a* coniferæ. (Pine, Larch, Cypress, &c.)

*b* cycadæ. (Cycas, &c.)

## 2. Angiosperms.

Seed covered, embryo dicotyledonous or acotyledonous.

(Spurges, Nettles, Oak, Elm, Rafflesia, (acotyledonous,) &c.)

## II. COROLLIFLORÆ.

1. Epipetalæ. (Primrose, Convolvulus, &c.)

2. Hypostamineæ. (Heaths, Epacrides.)

## III. CALYCIFLORÆ.

1. Monopetalæ. (Dandelion, Campanula, &c.)
2. Polypetalæ. (Rose, Pea, &c.)

## IV. THALAMIFLORÆ.

(Crow's-foot, Poppy, Geranium, &c.)

The preceding classes Endogens and Exogens, constitute the division Cotyledons of Authors, and Phanerogamia of Linnæus ; the same class with the class Acrogens constitute Vasculares.

## GENERAL REMARKS ON DISTRIBUTION OF PLANTS AND ANIMALS.

Geographic distribution of Species. Centres of Creation. Explanation of terms Fauna and Flora, Restricted Faunas and Floras, Local Faunas and Floras. Differences between Variety, Species. Extinct Species, Introduced Species, Causes of Extinction.

## ECONOMIC ZOOLOGY AND BOTANY.

Animal Substances used in Arts and Manufactures. General review of most important Animal Substances, oils, fats, skins, furs, hair, feathers, horn, bones. Mammals furnishing Oils. Natural History of Cetaceans. General History of Whale Fisheries—Right Whale, White Whale, Rorqual, Finback, Spermaceti Whale. Whalebone. Whales' Tooth Ivory—Narwhal. Dugong, Manatee. Natural History of Seals (Phocidae)—Seal Fishing, Oil Seals, Gray Seal, Sea Lion, Sea Elephant, Fur Seals, Seal Skin. Pisces—Fishes furnishing Oil—Basking Shark, White Shark, Sun Fish. Fish Oils; Cod Liver Oils, Isinglass, Shagreen.

Mammals furnishing hair, wool, horn. Ruminants—Various kinds of Horns—sources whence derived, Stag Horn, Imitation Tortoise-shell. Wool—sources whence derived, Vicugna, Llama, Alpaca, Cashmere Goat. Glue, Manufacture of. Pachyderms—Hides, sources whence derived, Tanning. Horse-hair. Pig's Bristles

Carnivora—Furs—Bear, Otter, Ermine, Sable, Lynx, Fox.

Rodentia—Hare, Rabbit, Chinchilla. Manufacture of Felt.

Reptilia—Tortoise-shell.

Insects—Wax Insects, Shell-lac Insect, Coccus Cacti, Bee, Silk-worm. Silk Manufactures. Mollusca—Cameos, Pearls.

Acrita. Sponges. Corals. Alimentary substances.

General Principles of Plant Life. Various Systems of which Plants are composed—Cellular System, Vascular System. Uses of Plants economically.

Natural history of Seaweeds; Edible Seaweeds—Dulse, Sloke or Laver, Carrigeen, Yeast plant. Iodine, its history, preparation. Kelp.

Natural history of Lichens; Edible Lichens—Tripe de Roche, Iceland Moss, Reindeer Moss. Tinctorial Lichens; general history of subject—brown dyes, yellow dyes, purple and blue dyes, Orchil, Cudbear, Litmus. Weeds and Mosses. *Roccella Tinctoria*.

General remarks concerning Plant Dyes. Colorific and Colorifiable products. Substantive and Adjective Colors—Indigo, Logwood, Weld, Fustic.

General observations regarding production of Starch, Sugar, Gums, in Vegetable Tissues. Organic Elements.

Natural history of Palms—Sago Palm, the history of preparation, Sago derived from other sources. *Cycas revoluta*. Other Starch compounds—Cabbage Palm, Betel Palm, Catechu, Date Palm, Oil Palms, Cocoa Palm, Cocoa Nut, Coir, Piasava, Jaggery, Arrack, Cocoa Nut Oil, Guinea Oil, Wax Palms, Resin Palms, Coquilla Nuts, Vegetable Ivory, Rattans, Cable Cane.

General observations on Resins and similar products.

Natural history of Conifers. Fossil Conifers; Amber, New Zealand Amber. Recent Conifers; Timber Trees—Larch, Pine, Spruce, Kaurie Pine, Norfolk Island Pine, Cedar, Red Cedar. Turpentines, modes of procuring. Resin, Pitch, Tar, manufacture of. Bark Bread of Norway. Stone Pine of Europe.

General observations on Woody Fibre. Natural History of Nettle-worts, Chinese Grass Cloth. Hempworts, Natural History of Order—Common Hemp, Indian Hemp and its products; General account of Manufacture of Hemp. Flax tribe—Flax and its Preparation. Papilionaceous order—Sunn Hemp. Linden order—Jute, Paat, Bast. Banana order—Manilla Hemp. Amaryllis order—Pita Flax. Mallow order—Common Mallow, *Hibiscus cannabinus*. Cellular tissue used for textile purposes. Cotton, its Manufactures.

Latex Laticiferous Vessels.

Bread Fruit Tribe; Natural History of Order—*Antiaris Saccadora*. Ant; *Toxicaria*. Mulberry order; Natural History of order—Paper Mulberry, Fig Tree, Fustic. Caoutchouc, sources whence derived, its history, mode of preparation. Sabadilla Tribe—Gutta Percha Tree, its history, uses.

General observations on Vegetable Oils, receptacles of Secretion.

Olive Tribe; Natural History of Order—Manufacture of Oil, Lucca Oil. Cabbage Tribe—Rape Oil. Other Vegetable Oils, fixed Oils—Hemp Oil, Linseed Oil, Poppy Oil, Cocoa Nut Oil, Palm Oil, Solid Oils, Volatile or Essential Oils. Properties of Labiate Tribe—Oil of Lavender, Oil of Spike. Laurel Tribe—Oil of Cassia, Oil of Cinnamon. Natural History and preparation. Camphor Tree, Borneo Camphor, Dutch Camphor. Nutmeg Tribe—Moluccas Nutmegs, South American Nutmegs. Oil of Cloves, Oil of Anise. General History of Spices.

Cerealia; Natural History of order. Parts of Plants used as food—fruit, leaf, stem, root, seed—Examples of. General conclusion.

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Books recommended as Class Books:—Balfour's Outlines of Botany. Milne Edwardes' Outlines of Zoology, (translated by Knox). Agazziz and Gould's Physiology. Lindley's School Botany.

## GEOLOGY.

*Professor, J. BEETE JUKES.*

Divided into :—

- A. PHYSICAL GEOGRAPHY.
- B. GEOGNOSY.
- C. PALÆONTOLOGY.
- D. HISTORY OF THE FORMATION OF THE CRUST OF THE EARTH.

## PHYSICAL GEOGRAPHY.

1. Form of the Earth, its Specific Gravity and Internal Heat. Question as to Fluidity or Solidity of Interior.

2. Unevenness of the Surface of the Earth—Hollows, or Depressions below a certain level, filled with water and called Seas and Oceans—Elevations above that level form Dry Land—Comparison of the Area, the Shape or Contour, and the “Mould” or general form of the Land and of the bed of the Ocean—Mean Height of the Land, and Mean Depth of the Sea.

3. Land may be portioned out into Mountains and Hills, Table Lands, Plains, and Valleys—Mountain Chains may be classed as Principal and Subordinate—Two principal Mountain Chains, *a.* Indo-European Chain of Old World, running nearly East and West, *b.* Andes and Rocky Mountains of New World, running nearly North and South—Subordinate Chains numerous—Shape of Lands governed by direction of Principal and Subordinate Chains, or slope of Plains and Valleys depending on Mountain Chains as axes of elevation.

4. Mountain Chains composed of one range, or of two or more nearly parallel ranges, sometimes inosculating, sometimes divergent, sometimes connected, sometimes unconnected—and of lateral spurs running nearly at right angles to Chains.

Inosculating ranges enclose isolated Table Lands, or mountain Valleys; other ranges are separated or traversed by longitudinal and lateral Valleys.

5. Valleys connected together, so as to form a system of channels for conveying water into one central artery, producing a number of tributary streams to one main river.

Each system of Valleys forms a “Basin of Drainage.” Basins of Drainage, separated by “water sheds,” or ridges more or less abrupt, of elevated ground, from which the brooks fall each way.

Most Basins of Drainage empty themselves either directly or indirectly into the Ocean. Some are independent, and form inland Seas or Salt Lakes, often called Caspians.

6. Description of the most remarkable Mountain Chains and Basins of Drainage of the World.

Relation of the two principal Mountain Chains and their River Basins to the two great Oceans, the Atlantic and Pacific.

7. The Sea and the Atmosphere—their Physical and Chemical Constitution, extent, weight, colour, temperatures, and movements. Distribution of Temperature and consequent evaporation and circulation of moisture—Clouds, Rain, Hail, and Snow—Rainy and Dry Seasons and Districts.

Varied distribution of Temperature combined with the Motion of the Earth, is the cause of Currents in Air and Ocean—Trade Winds, Monsoons, Calms, Tyfoons, Cyclones, Oceanic Currents, Gulf Stream, &c.

Cause of Cold in Upper Regions of Atmosphere—Snow Line, —Glaciers, and Icebergs—their structure, origin, and movement.

8. Climate—depending on Latitude, on distribution of Land and Water, height and aspect of slope of Mountains, and direction of Winds and Currents—Climate of Western Coast of Europe contrasted with that of Eastern Coast of North America—West Coast of North America contrasted with East Coast of Asia—Climates of South America and Australia described and accounted for and compared with each other and that of South Africa. Deserts of Old and New World accounted for according to Maury's Theory of the Circulation of the Winds.

#### 9. Geological action of Moving Water.

Chemical action in Dissolving Mineral Matter, as Silica, Carbonate of Lime, &c.—Hot Springs or Geysers, Petrifying Wells and Springs, Tufa, Travertine, Stalactites in Caverns—Conveyance of Dissolved Carbonate of Lime, Gypsum, Salt, &c., into the Sea—Origin of the Saltiness of the Ocean and of Caspians or Inland Seas.

Mechanical action in disintegrating and conveying Mineral Matter—Springs, Rain, Ice, Brooks and Rivers, Cataracts and Waterfalls, formation of Deltas, transport of Rock by Glaciers and Icebergs—Erosive action of Sea Breakers and carrying power of Tides and Currents—Formation of Cliffs, Precipices and Ravines—Deposit of Mud Banks and Sand Banks, and shallowing of narrow Seas.

Absence of Mechanical Deposits in bed of great Ocean—Soundings in North Atlantic—Infusorial Clay.

10. Coral Reefs, their form, their extent, and distribution—Proof of the Origin of Limestone in the Organo-Chemical Action of Animals on the Carbonate of Lime dissolved in the Sea—Vertical thickness and steepness of Coral Reefs—Proof of Depression of the Ocean Bed.

11. Geographical distribution of Animals and Plants laterally and vertically—Specific and Generic Centres—Relation of these subjects to Physical Geography and Geology.

12. Volcanoes and Earthquakes—Structure of a Volcanic Mountain—Cone and Crater—Ashes, Cinders, and Lava—Von Buch's elevation theory untenable—Subaerial and Submarine Volcanoes—remarkable Volcanic Eruptions—Active and Extinct Volcanoes—Distribution of Volcanoes—Connexion of Earthquakes and Volcanoes—Examples of remarkable Earthquakes—The Phenomena accompanying them—Mr. Mallett's Catalogue and Descriptions—Origin of Volcanic action.

13. Permanent elevation and depression of land during Earthquakes—Gradual elevation and depression of land without Earthquakes—Examples of each kind of motion in our own times.

The existence of Dry Land, that is, of Rock once below and now above the level of the sea, due entirely to the action of elevatory forces such as are now at work.

14. Proofs of the Physical Geography and Climate of the British Islands and Western Europe having been formerly different from what they are now, the Mountains having been covered by perpetual Snow, with Glaciers, although the land stood at a lower level than it now does, and was consequently to a great extent covered by the Sea which was then encumbered with Icebergs—Arctic Shells then in the Irish Sea.

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## GEOGNOSY.

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Subdivision of Geognosy into Lithology and Petrology.

### PART I.—LITHOLOGY,

Or the study of the Mineral composition and structure of Rocks. Based on Mineralogy. Definition of the terms “Mineral,” and “Rock.”

1. Enumeration of the Substances which enter most abundantly into the composition of Rocks.

One simple substance.

*Carbon*, in the Minerals—Diamond and Graphite, and in the Rock—Coal.

One Primary Compound.

*Silica*, in the Mineral—Quartz.

The following Secondary Compounds.

*Carbonates*, Calcite, Dolomite.

*Sulphates*, Gypsum, Anhydrite.

*Silicates*, The Hornblendes, the Garnets, the Micas, the Felspars, and the Zeolites.

2. Crystallization of Minerals:—Original fluidity of crystallized Minerals either from *solution* or *fusion*. Therefore all rocks formed of crystallized Minerals, either precipitated from solution, or consolidated from fusion. Crystalline rocks composed of *soluble* minerals are Aqueous, those composed of insoluble but *fusible* minerals are Igneous. These, whether aqueous or igneous, may be called *Chemically* formed Rocks.

3. Rocks composed of rounded or triturated *fragments* of Minerals are deposited from mechanical suspension in Water or Air, and may therefore be called *Mechanically* formed Rocks. They are principally Aqueous, the exceptions being Aerial.

4. Rocks composed of fragments of animals or plants, may be called *Organically* formed Rocks. These are either Aqueous, or Terrestrial in origin.

5. Rocks altered by Heat or other agency from their original condition, may be called *Metamorphic* (or transformed) Rocks.

Description of Rocks:—

6. IGNEOUS ROCKS. Principally *chemical* compounds, but having some *mechanical* accompaniments.

Cindery, glassy, slaggy, stony, and porphyritic structures.  
*Volcanic.* Trachytes, or felspathic Lavae, with Obsidian and Pumice. Clinkstone.

Dolerite, or Augitic Lavae. Basalt.

Intermediate Lavae, or Trachy-dolerite.

Tuff and Peperino, or Volcanic Ashes, breccias and conglomerates.

*Trappean.* Felstone, or felspathic traps.—Clinkstone.

Greenstone, or hornblendic traps—Basalt—Amygdaloid.

Intermediate traps.

Porphyry, Syenite.

Trappean ashes, tuffs, and breccias or conglomerates.

*Granitic*, or super-silicated Rocks.

Syenite.

Elvanite or Quartziferous Porphyry.

Eurite.

Protogine.

Pegmatite.

Granite.

Deep formed, or hypogenous, no ashes.

7. AQUEOUS ROCKS. Principally mechanical, but many chemical, organic, or mixed.

*Mechanical.* { *Arenaceous.* Sand, Gravel, Sandstone, Gritstone, Conglomerate, Rock, Rotch or Roche, Post, Griddle, Peldon, Calliard or Galliard, Flagstone, Freestone, &c.

*Argillaceous.* Mud, Clay, Loam, Shale, Clunch, Marl, Clayslate, Fireclay, Batt, or Bass, Bind, Metal, Plate.

*Chemical.* — Gypsum, Rocksalt, Magnesian limestone.

*Organic.* { *Calcareous.* From animals, Limestone, Chalk, Oolite, Shell Marl, &c.

*Carbonaceous.* From plants, Coal, Lignite, Peat, &c. Mingling and union of the mechanical, chemical, or organic forces in the production of many varieties of rock.

8. AERIAL ROCKS. Blown Sand and other accumulations, incoherent or concreted.

Volcanic tuff, &c., from ashes falling on land.

9. METAMORPHIC ROCKS. Igneous or Aqueous Rocks, altered by Heat, Pressure, or by Chemical agency.

*Arenaceous.* Quartz rock, or quartzite, &c.

*Argillaceous.* Clay-slate, &c.

*Calcareous.* Statuary and other marbles. Dolomite.

*The Schistose Rocks.* Micaschist, Chlorite,—Talc,—Hornblende,—and other schists, Gneiss.

10. Concretionary, nodular, fibrous, and radiated structures, and segregation of mineral matter. Flint in Chalk, Chert in Limestone, &c. Balls and crystals of Iron Pyrites, and other minerals, in nests and geodes, and drusy cavities.

11. Decomposition and weathering of rocks. Percolation of water containing carbonic and other acids. Substitution and replacement of minerals.

12. Petrification and mineralization of organic and other bodies.

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GEOGNOSY.—Part 2nd.

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PETROLOGY,

Or the study of Rock Masses.

1. Stratification and Lamination, regular and irregular, lenticular and oblique ; thickening and thinning out, extent and termination of beds. Ripple or Current mark.

Erosion and filling up of beds, in course of formation. Pot holes, sink holes, swallow holes, pipes, sandgalls, rolls, swells, horses' backs, rock-faults, balks, symon faults.

2. Interstratification and alternation of different kinds of beds. Result of variations in direction or force of currents, floods of Rivers, &c.

Necessity of dry land for production of mechanical rocks.

3. Joints in Aqueous and Igneous rocks. Cuboidal and Prismatic joints. Art of Quarrying.

Spheroidal structure. Columnar structure.

4. Cleavage, or superinduced fissility of rocks.

Foliation, or superinduced separation into plates of different substances.

5. Forms of Igneous Rocks. Underlying, intrusive, and overlying masses, dykes and veins.

6. Elevation and depression, inclined position of beds, Dip, Strike, Anticlinal, and Synclinal curves, Axis of elevation or depression, Qua-qua-versal dip, Contortions.

Dislocation, Fissures, Faults, Mineral veins, upthrow, downthrow, lateral shift. Art of Mining.

7. Structure and direction of mountain chains, theory of M. Elie de Beaumont.

8. Relation of Igneous to Aqueous Rocks, metamorphic action.

9. Mineral veins, deposition of metallic ores and other minerals, association and distribution of ores. Transformation and replacement of minerals.

10. Denudation : its vast amount measured by amount of mechanically formed rocks, proved also by presence at surface of Granite and other deeply formed rocks.

11. Overlap, result of movement of depression.

Unconformability, result of movement of elevation, combined with denudation and subsequent depression. Search for coal, water, &c.

12. Grouping and classification of Rocks. Sets or stages, Formations, Systems.

- Superposition of beds involves succession of time.
- Periods of deposition and production, Periods of rest, Periods of destruction, Periods of transformation.
- Value of interval between beds of similar and beds of dissimilar rock.
- Value of interval between groups of conformable beds.
- Value of interval between unconformable groups.

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## PALÆONTOLOGY.

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The Zoology and Botany of the past, or the study of Fossils.

1. Fossils are the remains of animals or plants either of extinct or existing species, which have been buried in the earth by natural causes. Animals and plants are either aquatic or terrestrial. The aquatic, as being necessarily the most abundantly preserved in aqueous rocks, form the most numerous and important fossils. The terrestrial kinds in order to become fossils must have either been carried down into the water and sunk there, or have been buried under subaerial accumulations on the present lands, or on former terrestrial surfaces that have been covered up and preserved to us.

Plants are mostly terrestrial, and, therefore, comparatively few are found fossil. Of animals the greater number, whether of individuals or of species, are aquatic, principally marine.

2. Of the Vertebrata the skeletons of a few land Mammalia and still fewer Birds have, under peculiar circumstances, been more or less perfectly preserved; but the skeletons of many Reptiles (principally marine) and the bones and scales of Fish are the most important Vertebrate Fossils.

3. Of the Mollusca, all those having Shells or other hard parts are *most important* and are the principal study of the Palaeontologist.

4. Of the Articulata a few Insects have been preserved, but the Crustacea, as being more entirely marine, are the most important.

5. Of the Radiata, Echinodermata and Corals are most important.

6. The Testaceous Mollusca afford a more complete and unbroken scale of comparison than all other Fossils.

The *fossil* Testaceous Mollusca of the British Islands are about eight times as numerous as the *living* Testacea of the British Islands, (compare Forbes and Hanley with Morris's Catalogue.)

There must probably therefore be at least eight Fossil marine Fauna in the British Islands as numerous in species as the existing Fauna, or portions of more than eight such Fauna.

7. The ten Palaeontological "laws" or generalizations of Pictet:—

I. Species of animals have all had a limited Geological duration.

II. Species which were contemporaneous in one locality or in neighbouring localities, have in the immense majority of instances appeared and disappeared together.

III. The differences which exist between extinct Faunas and living animals are by so much the greater as the extinct Faunas are more ancient.

IV. The animals of recent Faunas have more varied forms than those of ancient Faunas, that is to say, the diversity of animal organization has been augmenting in the lapse of time. (?)

V. The most perfect animals have a relatively recent origin. (?)

VI. The order of appearance of the different types of animals on the surface of the earth often recalls to mind the phases of embryonic development. (?)

VII. From the moment when a zoological type has appeared for the first time to the moment when it has disappeared altogether, there has been no interruption in its existence.

VIII. The comparison of the Faunas of the different epochs shows that the temperature of the surface of the earth has varied.

IX. The species which lived in ancient epochs had a more extended geographical distribution than those which exist in our day. (?)

X. Fossil animals have been constructed on the same plan as those animals now living, and their life has manifested itself by identical physiological acts.

Examination of these so called "Laws" those numbered IV., V., VI., and IX. shown to be very doubtful, or capable of a double interpretation, while the truth of No. II. depends on the completeness or incompleteness of the series of deposits or aqueous rocks, and the fitness of each bed for the preservation of organic remains.

"Facies" of assemblages of Fossils, a term invented by Von Buch.

8. Professor Edward Forbes' doctrine of specific and generic centres. The limited distribution of species in space, the consequence of this doctrine. His discoveries as to the limited *vertical* distribution of marine life.

9. Question as to the life or duration of a species. Notion as to its having a term of life originally limited, like that of an individual, probably unfounded.

Duration of a species depending on external circumstances and its power of adapting itself to them. Species having greatest lateral and vertical range in space have greatest length of duration in time.

Extinction of species due to change of conditions of habitat, or to introduction of other hostile species—Extinction of Dodo, &c.

10. Introduction of new species due either to direct creation or to some yet unknown physiological law, acting at rare intervals. Doctrine of development unfounded and improbable.

Succession of races of animals and plants, gradual introduction of new species and extinction of old. Hypothesis of general destruction and creation unfounded.

11. Practical and economic importance of chronological succession of Fossils. Same chronological succession observable in every class of Fossils. Harmony of result whether we classify Fossil Plants, Fossil Corals, Echinodermata, Crustacea, Mollusca, Fish, Reptiles, or Mammalia, singly or in groups.

Agreement of Palaeontological classification with that of purely Physical Geology.

## HISTORY OF THE FORMATION OF THE CRUST OF THE GLOBE.

Terms applicable either to periods of time, or to the rocks formed in those periods. This ambiguity a frequent source of confusion and mistake.

Some terms derived from nature of rock, some from geographical situation of rocks, some from relative date of formation.

Dismissing the derivation of terms—consider the following as signifying only *periods of time*, following in succession, and divided into three great epochs.

### PRIMARY OR PALÆOZOIC EPOCH.

- a. Cambrian period.
- b. Lower Silurian , ,
- c. Upper Silurian , ,
- d. Devonian , ,
- e. Carboniferous , ,
- f. Permian , ,

### SECONDARY OR MESOZOIC EPOCH.

- g. Triassic period.
- h. Oolitic or Jurassic , ,
- i. Wealden (or Neocomian ?) , ,
- j. Cretaceous , ,

### TERTIARY OR KAINOZOIC EPOCH.

- k. Eocene period.
- l. Miocene , ,
- m. Pliocene , ,
- n. Pleistocene , ,
- o. Recent or Historical. , ,

Proposed modification by Professor Edward Forbes into two epochs only, namely, Palæozoic and Neozoic.

Description of Particular or Typical Groups of Rocks formed during the above periods, and of their most characteristic Fossils, according to the following abstract.

### PRIMARY OR PLÆOZOIC EPOCH.

#### a. CAMBRIAN PERIOD.

*Fossils.*—Oldhamia, Trilobites ? Annelid tracks and Fucoids.

*Typical Groups of Rocks.*

*Wales.*—Longmynd, Barmouth and Harlech, and Anglesea Rocks.

*Ireland.*—North Wicklow and South Wexford Rocks.

*Cumberland.*—Skiddaw Slate, &c.

*Bohemia.*—Stage A, Crystalline Schists; and Stage B, Argillaceous Slate and Conglomerate (Barrande.)

*b. LOWER SILURIAN PERIOD.**Middle and Upper Cambrian of Professor Sedgwick.*

*Fossils.*—Peculiar species of Corals and other Zoophytes, Echinodermata, Crustacea (Trilobites), Brachiopoda, Lamellibranchiata, Gasteropoda and Cephalopoda. Cystidea, Crinoidea and Strophomenidae very abundant.

*Typical Groups of Rocks.*

*Wales.*—*b* 1. Lingula Flags. *b* 2. Llandeilo beds. *b* 3. Bala and Caradoc beds.

*Bohemia.*—*b* 1. Stage C of Barrande, argillaceous slate. *b* 2. Stage D of Barrande, quartzites.

*North America.*—*b* 1. Potsdam Sandstone. *b* 2. Calciferous Sandstone. *b* 3. Chazy Limestone. *b* 4. Birdseye Limestone. *b* 5. Black River Limestone. *b* 6. Trenton Limestone. *b* 7. Utica Slate. *b* 8. Lorraine Shales and Sandstones, or Hudson River group.

*c. UPPER SILURIAN PERIOD.*

*Fossils.*—Peculiar species of animals of the classes mentioned above, with fragments of Fish in addition, and with other gigantic Crustacea, besides Trilobites. The species generally different from those living in the preceding or succeeding periods. Some species found only in one of the typical groups.

*Typical Groups of Rocks.*

*England.*—*c* 1. Mayhill Sandstone. *c* 2. Wenlock Shale and Limestone. *c* 3. Ludlow Rocks, with Aymestrey Limestone. *c* 4. Tilestone.

*Bohemia.*—*c* 1. Stage E, Calcaire inferieur. *c* 2. Stage F, Calcaire Moyen. *c* 3. Stage G, Calcaire superieur. *c* 4. Stage H, Schistes culminants (Barrande).

*North America.*—*c* 1. Grey Sandstone. *c* 2. Oneida conglomerate. *c* 3. Medina Sandstone. *c* 4. Clinton group. *c* 5. Niagara group. *c* 6. Onondaga Salt group. *c* 7. Tentaculite Limestone. *c* 8. Pentamerus Limestone. *c* 9. Delthyris Shaly Limestone. *c* 10. Encrinus Limestone. *c* 11. Upper Pentamerus Limestone.

*d. DEVONIAN PERIOD.*

*Fossils.*—Some Plants, and many very remarkable Fish, with one small Reptile, in addition to other and peculiar species of animals belonging to the classes mentioned before.

*Typical Groups of Rocks.*

*Devon and Cornwall.*—*d* 1. Liskeard or Ashburton group. *d* 2. Plymouth group. *d* 3. Dartmouth group. *d* 4. Marwood and Barnstaple Rocks, and Petherwin group, (probably of the Carboniferous period.)

*South Wales and Hereford.*—Old Red Sandstone. *d* 1. Cornstone group. *d* 2. Red Sandstone and Conglomerate.

*Scotland.*—Old Red Sandstone in three subdivisions. *d* 1. Caithness group. *d* 2. Grey Sandstone. *d* 3. Red and Yellow Sandstone, with concretionary Limestone.

*Ireland*.—Old Red Sandstone. *d* 1. Green and Purple Grits and Slates. *d* 2. Purple and Red Sandstones and Slates, with calcareous bands. *d* 3. Red, Green, and Yellow Sandstones and Shales.

*The Rhine*.—*d* 1. The Coblenz group. *d* 2. The Ahr group. *d* 3. The Eifel group.

*North America*.—*d* 1. Oriskanny Sandstone. *d* 2. Cauda-Galli and Schoharrie Grit. *d* 3. Onondaga and Corniferous group. *d* 4. Marcellus Shales. *d* 5. Hamilton group. *d* 6. Tully group. *d* 7. Genesee and Portage group. *d* 8. Chemung group. *d* 9. Catskill group, or Old Red Sandstone.

#### e. CARBONIFEROUS PERIOD.

*Fossils*.—A vast abundance of Plants—Ferns, and Forest Trees, and others of unknown affinities. Peculiar species of all the classes of animals mentioned before, with several Reptiles. The Cephalopoda especially numerous, and some of them (as *Orthoceras*) gigantic. *Crinoidea*, *Productidae*, and *Spiriferidae* very abundant.

#### Typical Groups of Rocks.

*Ireland*.—*e* 1. Coomhola Grits. *e* 2. Carboniferous Slates—(Yellow Sandstone of Dr. Griffith.) *e* 3. Lower Limestone. *e* 4. Calp. *e* 5. Upper Limestone. *e* 6. Millstone Grit. *e* 7. Coal-measures.

*South Wales*.—*e* 1. Lower Limestone Shales. *e* 2. Carboniferous Limestone. *e* 3. Millstone Grit, or Pennant Rock. *e* 4. Coal-measures.

*Derbyshire*.—*e* 1. Carboniferous Limestone. *e* 2. Limestone Shale. *e* 3. Millstone Grit. *e* 4. Coal-measures.

*York and Durham, &c.*.—*e* 1. Great Scar Limestone. *e* 2. Yoredale Series. *e* 3. Millstone Grit. *e* 4. Coal-measures.

*Scotland*.—*e* 1. Calciferous Sandstone (Maclarens). *e* 2. Lower Carboniferous Group, containing Limestone interstratified with Shales, Sandstones, and Coals. *e* 3. Upper Carboniferous or Coal-Measures, with little or no Limestone.

#### f. PERMIAN PERIOD.

*Fossils*.—Peculiar species of most of the classes mentioned before, (no Trilobites,) Fish abundant in the Magnesian Limestone and Zechstein Group.

#### Typical Groups of Rocks.

*Perm in Russia, and Germany*.—*f* 1. Rothetodteligende. *f* 2. Zechstein and Kupfer schiefer. *f* 3. Lower Bunter Sandstein.

*Durham and Yorkshire*.—*f* 1. Lower Red Sandstone. *f* 2. Magnesian Limestone.

#### SECONDARY, OR MESOZOIC EPOCH.

#### g. TRIASSIC PERIOD.

*Fossils*.—Very imperfectly known; mostly footprints of large Batrachian and other Reptiles in Britain; footprints of Birds in America; many shells, &c., of peculiar species in the Muschelkalk. Cephalopoda (Ammonites) intermediate in character between Palaeozoic and Oolitic, Fish and Saurian Reptiles in Germany and the Bone bed.

*Typical Groups of Rocks.*

*Germany.*—*g* 1. Bunter Sandstein. *g* 2. Muschelkalk. *g* 3. Keuper.

*England.*—*g* 1. Red and Mottled Sandstone, with pebble beds, breccia, and calcareous conglomerate in centre. *g* 2. Dolomitic conglomerate (local). *g* 3. White Sandstone, with calcareous conglomerate and breccia. *g* 4. Red and Variegated Marls, with interstratified Sandstones, and with thick and thin local beds of Gypsum and Rock Salt. *g* 5. Bone Bed.

*OOLITIC, OR JURASSIC PERIOD.*

*Fossils.*—Peculiar species of Plants, Corals, Echinodermata, and of all other classes of marine animals which have any hard parts. Large Marine and Terrestrial Saurian Reptiles, very abundant in the Lias; Some winged Reptiles; some Insects, and a few small Terrestrial Mammalia, (*Marsupials*.)

*Typical Groups of Rocks.*

*South England.*—(Lias) *h* 1. Lower Lias Shale and Limestone. *h* 2. Marlstone. *h* 3. Upper Lias Shale.—(Lower Oolitic or Bath Group) *h* 4. Inferior Oolite Sand and Limestone. *h* 5. Fuller's Earth. *h* 6. Great Oolite. *h* 7. Forest Marble. *h* 8. Cornbrash.—(Middle Oolitic, or Oxford Group) *h* 9. Oxford Clay. *h* 10. Coral Rag.—(Upper Oolitic, or Portland Group) *h* 11. Kimmeridge Clay. *h* 12. Portland Sand and Stone. *h* 13. Purbeck Beds.

*Yorkshire.*—(Lias) *h* 1. Lower Lias Shale. *h* 2. Marlstone. *h* 3. Upper Lias Shale.—(Lower Oolitic Group) *h* 4. Subcalcareous Ferruginous Sand, *h* 5. Sandstone, Shale, Ironstone, and Coal. *h* 6. Impure Oolitic Limestone. *h* 7. Sandstone, Shale, Ironstone, and Coal. *h* 8. Shelly Limestone, Cornbrash.—(Middle Group) *h* 9. Oxford Clay. *h* 10. Coral Rag.—(Upper Group) *h* 11. Kimmeridge Clay. *h* 12 and *h* 13 are wanting in Yorkshire, and the Coral Rag is wanting at many places between Yorkshire and Gloucestershire.

Carboniferous aspect of Lower Oolite Group retained in Scotland, and reappears in America and India, where good coal is obtained from it.

*i. WEALDEN PERIOD,*

(Which perhaps ought to be called Neocomian.)

*Fossils.*—In the fresh water beds, many Plants and fresh water and estuary Shells, skeletons of gigantic Terrestrial Reptiles. In the marine beds peculiar species of Marine Shells and other Fossils.

*Typical Groups of Rocks.*

*South-East of England.*—*i* 1. Hastings Sand. *i* 2. Weald Clay. *i* 3. Lower Greensand and Kentish Rag, (Speeton Clay of Yorkshire).

*Neufchatel.*—Thick Yellow Limestones, with interstratified blue marl, divisible into three groups.

The true Wealden beds being merely fresh-water and estuary, (in fact, a "fossil delta" of some large river,) ought to be referred to their contemporaneous marine strata, and it is probable that these strata are Neocomian.

## j. CRETACEOUS PERIOD.

Peculiar species of all classes of animals that had any hard parts, with the exception of Birds and Mammals, of which no remains have as yet been found. Echinoidea very abundant in the chalk.

## Typical Groups of Rocks.

*England, France, &c.*—(Lower Group) *j* 1. Gault. *j* 2. Upper Green sand.—(Upper Group) *j* 3. Chalk Marl. *j* 4. Chalk without flints. *j* 5. Chalk with flints. *j* 6. Maestricht or Pisolitic Beds.

*North Germany.*—Quadersandstein, a brown ferruginous Sandstone and Planer kalk represent the upper Chalk.

*South America.*—Some of the Cretaceous Rocks are blue clay slate.

## KAINOZOIC, OR TERTIARY EPOCH.

## k. EOCENE PERIOD.

*Fossils.*—Many Plants—Palm Fruits in the Island of Sheppey. Peculiar species of almost every class of animals, without exception, including Birds and Mammals. Of the Shells, few are Brachiopoda, of the other Shells a few (not more than 5 per cent.) are still living at the present day. Many extinct Pachydermata in France, found in the fresh-water beds. Turtles and Crocodiles in London Clay, &c. Nummulites very abundant in Southern Europe and Asia, along the southern flanks of the great Indo-European chain.

## Typical Groups of Rocks.

*Middlesex and Hampshire.*—(Lower Group) *k* 1. Thanet Sands. *k* 2. Woolwich Beds, or Plastic Clay. *k* 3. London Clay. (Middle group), *k* 4. Bagshot and Bracklesham Beds. *k* 5. Barton Clay. *k* 6. Headon Beds. *k* 7. St. Helen's Beds. (Upper group), *k* 8. Bembridge Beds. *k* 9. Hempstead Beds.

*North France.*—(Lower Group) *k* 1. Sable de Bracheux. *k* 2. Argile Plastique. *k* 3. Lignites des Soissonnais. (Middle group), *k* 4. Lits Coquilliers. *k* 5. Glaucopie Grossier. *k* 6. Calcaire Grossier. *k* 7. Gres de Beauchamp. *k* 8. Calcaire de St. Ouen. (Upper group), *k* 9. Gypseous series of Montmartre, in three bands of Gypsum, interstratified with Marls and fresh-water Limestone. *k* 10. Fontainebleau Sands. *k* 11. Calcaire de Beaune.

In these two series, the Hempstead Beds=Fontainebleau Sands; the Calcaire Grossier or the Gres de Beauchamp=the Barton Clay; the Lits Coquilliers=Lower Bagshot Sands; the Lignites des Soissonnais=Fluviatile Beds of Woolwich; and Sable de Bracheux=Lower Woolwich Beds. The London Clay and Thanet Sand have no representatives in France, (Prestwich).

*Great Lakes and Volcanoes in central France—Volcanic Cones and Lava Streams still preserved, many of these, however, probably belong to a subsequent period.*

## l. MIocene PERIOD.

*Fossils.*—Shells, of which about 18 or 20 per cent. are still living. Extinct Mammalia, such as the Deinotherium, &c.; probably Plants associated with basalt of Scotland and North of Ireland.

*Typical Groups of Rocks.*

*France*.—The faluns of Touraine ; the Bourdeaux Beds.

*Switzerland*.—The Molasse.

*Italy*.—Part of the Sub-Appenine Beds.

*Britain*.—Possibly the Basalt of N. Ireland, and W. Scotland.

*North America*.—Beds of North Carolina, Maryland, Virginia, and Delaware.

*m. PLIOCENE PERIOD.*

*Fossils*.—Shells of which about 50 per cent. are still living ; Bones of Whales and of Terrestrial Mammalia.

*Typical Groups of Rocks.*

*England*.—*m 1*. Coralline Crag. *m 2*. Red Crag.

*Italy*.—Major part of Sub-Appenine Beds ; Seven Hills of Rome.

*Asia*.—Aralo-Caspian formations.

*n. PLEISTOCENE PERIOD.*

*Fossils*.—Shells of which 90 per cent. or thereabouts are still living, either in the immediate neighbourhood of the places where they are found fossil or in other and sometimes distant localities. Mammalia in great abundance, owing to preservation of land surfaces. Mammoth, Mastodon, extinct species of Hippopotamus and Rhinoceros, gigantic Bears, Hyenas, Lions, and Tigers, &c., in Europe ; Great Elk in Ireland and Isle of Man ; Mastodon, &c., in North America ; Megatherium, Mylodon, and Glyptodon, in South America. Many extinct species of Elephants, and Sivatherium, Camel-leopards &c., in India ; gigantic Kangaroos, Wombats and Wallabis in Australia, with one Mastodon ; gigantic Emu-like Birds, Dinornis, &c. in New Zealand.

*Typical groups of Rocks.*

*England*.—Mammiferous Crag of Norwich. Glacial and other drifts. Marl of South of Ireland. Limestone gravel and Escars of central Ireland. Raised Beaches. Submarine Forests. Bone Caves.

*Sicily*.—Great formations several hundred feet thick and rising 3,000 feet above sea, although full of Shells of same species as those in Mediterranean.

*The Rhine*.—Loess.

*North America, and other countries*.—Drift and superficial accumulations.

Applications of Geology to Agriculture best considered here.

*o. RECENT OR HISTORICAL PERIOD.*

*Fossils*.—Still existing animals and plants. Human skeleton and bones in coral-sand, beaches, &c.

*Typical Groups of Rock.*

Lacustrine formations. Peat bogs. Deltas of rivers. Coral reefs. Sand dunes. Mud banks, &c.

Physical Geography of present day the result of above, though a preliminary knowledge of it necessary to understand geological action.

## CHEMICAL OPERATIONS AND ANALYTICAL CHEMISTRY.

The chemical laboratory of the Museum of Irish Industry will be opened during the session, from eleven o'clock, A.M., to three o'clock, P.M., every day, Saturdays and the periods of the Christmas and Easter recesses excepted. Two short courses of lectures will be given in the laboratory during the session, of which the subjoined syllabus will explain the character. The fee for the entire session will be £7, or for three months £3 10s., payable on registration. In addition to this sum a deposit of £1 10s. will be required, from which the cost of all apparatus broken or injured will be deducted at the end of the session.

Should an Evening Class be formed like that of last session, the same system of instruction as that adopted for the Day Class will be carried out. The arrangements as to hours and fees will be made after the formation of the class, as on the former occasion.

## FIRST OR JUNIOR COURSE.

*On Chemical Operations and the Elements of Qualitative Chemical Analysis.*

*Apparatus.*—Names of the commoner apparatus used by chemists. Bending and Cutting of Glass Tubes, and Piercing of Corks, and other operations required to set up and combine different pieces of apparatus.

*Operations.*—Pulverization, Levigation, and Edulcoration, Solution, Filtration of Liquids, Evaporation, Distillation, Precipitation, Filtration of Liquids from Precipitates, Washing of Precipitates, Desiccation, Ignition, Sublimation, Fusion, Fluxing, &c. Use of the Blowpipe.

*Gas Manipulation.*—Preparation and collection of gases, transference, solution in water, methods of employing gases in analysis, &c.

*Analysis.*—Preparation and purification of the various re-agents commonly employed.

Properties of the more important basic compounds of the metals. Detection of, and separation from one another, of those bases. Properties of the more important acids. Detection and separation of them from one another, and from bases.

## SECOND OR SENIOR CLASS.

*Elements of Quantitative Chemical Analysis.*

1. Methods of separating and determining the quantity of the more important bases and acids, illustrated by the complete analysis of a number of natural and artificial compounds.

2. Analysis of commercial materials and products:—Alkalimetry, chlorimetry, assaying of ores, flour, oils, soaps, tanning materials, dye stuffs, manures, &c.

3. Volumenometric testing in all its applications.

The character of the part of the course to be devoted to commercial testing by weight and volume will of course vary with the wants of the students composing the class.

TABLE OF THE DAYS AND HOURS OF LECTURE DURING THE SESSION.

OCTOBER.

Month of Days of	Day of Week	Day Lectures.		Evening Lectures.	
		Subject.	Place of Delivery.	Subject.	Place of Delivery.
9	THURSDAY,	Opening Address by the Director.	Theatre Museum of Irish Industry.		
13	MONDAY,	Introductory Lecture by the Professor of Physics.	Theatre of the Royal Dublin Society.		
14	TUESDAY,				
15	WEDNESDAY,	Physics.	"		
16	THURSDAY,	"	"		
17	FRIDAY,	"	"		
20	MONDAY,	"	"		
21	TUESDAY,	"	"		
22	WEDNESDAY,	"	"		
23	THURSDAY,	"	"		
24	FRIDAY,	"	"		
27	MONDAY,	"	"	{ Opening Lecture by the Professor of Geology.	Theatre of the Museum of Irish Industry.
28	TUESDAY,	"	"		
29	WEDNESDAY,	Introductory Lecture by the Professor of Chemistry.	Theatre of the Royal Dublin Society.	{ Evening Lecture by the Professor of Geology.	Theatre of the Museum of Irish Industry.
30	THURSDAY,				
31	FRIDAY,	"	"	"	"

## NOVEMBER.

Day of Month.	Day of Week.	Day Lectures.		Evening Lectures.	
		Subject.	Place of Delivery.	Subject.	Place of Delivery.
3	MONDAY,	Chemistry.	Theatre of Royal Dublin Society.	Geology.	{ Theatre of the Museum of Irish Industry.
4	TUESDAY,	"	"	"	"
5	WEDNESDAY,	"	"	"	"
6	THURSDAY,	"	"	"	"
7	FRIDAY,	"	"	"	"
10	MONDAY,	"	"	"	"
11	TUESDAY,	"	"	"	"
12	WEDNESDAY,	"	"	"	"
13	THURSDAY,	"	"	"	"
14	FRIDAY,	"	"	"	"
17	MONDAY,	{ Introductory Lecture by Professor of Natural History.	"	"	"
18	TUESDAY,	Zoology.	Mr. J. H. Madge's Museum, 1, Upper Parliament Street.	"	"
19	WEDNESDAY,	George Wight,	Mr. J. H. Madge's Museum, 1, Upper Parliament Street.	"	"
20	THURSDAY,	"	Examination by Prof. of Geology.	"	"
21	FRIDAY,	"	Opening Lecture by the Professor of Chemistry.	"	"
24	MONDAY,	"	Dr. A. Venetian.	"	"
25	TUESDAY,	"	Dr. A. Venetian.	"	"
26	WEDNESDAY,	"	Dr. A. Venetian.	"	"
27	THURSDAY,	"	Dr. A. Venetian.	"	"
28	FRIDAY,	"	Dr. A. Venetian.	"	"

## DECEMBER.

Day of Week. Monday,	Subject.	Day Lectures.		Subject.	Evening Lectures.	
		Place of Delivery.	Place of Delivery.		Place of Delivery.	Place of Delivery.
1 MONDAY,	Zoology.	{ Theatre of the Royal Dublin Society.	{ Chemistry.	{	Theatre of the Museum of Irish Industry.	
2 TUESDAY,	"	"	"	"	"	
3 WEDNESDAY,	{ Introductory Lecture by the Professor of Geology.	"	"	"	"	
4 THURSDAY,	Geology (Physical Geography).	"	"	"	"	
5 FRIDAY,	"	"	"	"	"	
8 MONDAY,	"	"	"	"	Museum of Natural History.	
9 TUESDAY,	"	"	"	"	Evening Lectures with Professor of Geology.	
10 WEDNESDAY,	"	"	"	"	"	
11 THURSDAY,	"	"	"	"	"	
12 FRIDAY,	"	"	"	"	"	
15 MONDAY,	"	"	"	"	"	
16 TUESDAY,	"	"	"	"	"	
17 WEDNESDAY,	"	"	"	"	"	
18 THURSDAY,	"	"	"	"	"	
19 FRIDAY,	{ Christmas Recess commences; ends January 5th.	"	"	"	"	
22 MONDAY,	Lecture "Geology" —	Lecture "Museum of Natural History" —	Lecture "Museum of Natural History" —	{ Examination by the Professor of Chemistry.	Museum of Irish Industry.	
23 TUESDAY,	"	"	"	{ Christmas recess commences.	The Evening Lectures will not be resumed until Monday, March 7th.	
24 WEDNESDAY,	"	"	"	{ resumed until Monday, March 7th.	Evening Lectures.	

## JANUARY.

Month of Day of Week.	Day Lectures.			Evening Lectures.		
	Subject.	Place of Delivery.	Subject.	Place of Delivery.	Subject.	Place of Delivery.
5 MONDAY, •	Physics, 2nd Part.	Theatre Museum of Irish Industry.	5 MONDAY, •	Physics, 2nd Part.	5 MONDAY, •	Physics, 2nd Part.
6 TUESDAY, •	Chapman's "Physics for Engineers."	"	6 TUESDAY, •	Chapman's "Physics for Engineers."	6 TUESDAY, •	Chapman's "Physics for Engineers."
7 WEDNESDAY, •	"	"	7 WEDNESDAY, •	"	7 WEDNESDAY, •	"
8 THURSDAY, •	"	"	8 THURSDAY, •	"	8 THURSDAY, •	"
9 FRIDAY, •	"	"	9 FRIDAY, •	"	9 FRIDAY, •	"
12 MONDAY, •	"	"	12 MONDAY, •	"	12 MONDAY, •	"
13 TUESDAY, •	"	"	13 TUESDAY, •	"	13 TUESDAY, •	"
14 WEDNESDAY, •	"	"	14 WEDNESDAY, •	"	14 WEDNESDAY, •	"
15 THURSDAY, •	"	"	15 THURSDAY, •	"	15 THURSDAY, •	"
16 FRIDAY, •	"	"	16 FRIDAY, •	"	16 FRIDAY, •	"
19 MONDAY, •	"	"	19 MONDAY, •	"	19 MONDAY, •	"
20 TUESDAY, •	"	"	20 TUESDAY, •	"	20 TUESDAY, •	"
21 WEDNESDAY, •	"	"	21 WEDNESDAY, •	"	21 WEDNESDAY, •	"
22 THURSDAY, •	"	"	22 THURSDAY, •	"	22 THURSDAY, •	"
23 FRIDAY, •	"	"	23 FRIDAY, •	"	23 FRIDAY, •	"
26 MONDAY, •	"	"	26 MONDAY, •	"	26 MONDAY, •	"
27 TUESDAY, •	"	"	27 TUESDAY, •	"	27 TUESDAY, •	"
28 WEDNESDAY, •	"	"	28 WEDNESDAY, •	"	28 WEDNESDAY, •	"
29 THURSDAY, •	"	"	29 THURSDAY, •	"	29 THURSDAY, •	"
30 FRIDAY, •	"	"	30 FRIDAY, •	"	30 FRIDAY, •	"
31 SATURDAY, •	{ Examination by the Professor of Physics.		31 SATURDAY, •	Museum of Irish Industry.		

No Evening Lectures will be given during the Month of January.

Evening Lectures.

Museum of Irish Industry.

Evening Lectures.

Evening Lectures.

FEBRUARY.

Day of Week.	Day Lectures.	Day Lectures.	Day Lectures.	Place of Delivery.
Day of Month.	Exposition General and New Subjects.	Exposition of Old Subjects.	Exposition of Old Subjects.	Place of Delivery.
2	MONDAY,	Chemistry, 2nd Part.	Theatre Museum of Irish Industry.	
3	TUESDAY,	"	"	
4	WEDNESDAY,	"	"	
5	THURSDAY,	"	"	
6	FRIDAY,	"	"	
9	MONDAY,	"	"	
10	TUESDAY,	"	"	
11	WEDNESDAY,	"	"	
12	THURSDAY,	"	"	
13	FRIDAY,	"	"	
16	MONDAY,	"	"	
17	TUESDAY,	"	"	
18	WEDNESDAY,	"	"	
19	THURSDAY,	"	"	
20	FRIDAY,	"	"	
23	MONDAY,	"	"	
24	TUESDAY,	"	"	
25	WEDNESDAY,	"	"	
26	THURSDAY,	"	"	
27	FRIDAY,	"	"	
28	SATURDAY,			

**MAY—JUNE.**

Month or Day of Month	Day of Week.	Day Lectures.		Subject.	Place of Delivery.	Evening Lectures.	Place of Delivery.				
		Subject.	Place of Delivery.								
1	FRIDAY,	Natural History, 2nd Part, Examination by the Professor of Natural History.	Theatro Museum of Irish Industry.	Opening Lecture by the Professor of Natural History.	Theatre of the Royal Dublin Society.	Examination by the Professor of Natural History.	Theatre of the Royal Dublin Society.				
2	SATURDAY,	Museum of Irish Industry.	Theatro Museum of Irish Industry.								
4	MONDAY,										
5	TUESDAY,	Examination by the Professor of Natural History.	Theatro Museum of Irish Industry.								
6	WEDNESDAY,										
7	THURSDAY,										
8	FRIDAY,										
11	MONDAY,										
12	TUESDAY,										
13	WEDNESDAY,										
14	THURSDAY,										
15	FRIDAY,										
18	MONDAY,	No Day Lectures during the remainder of the Session.	Examination by the Professor of Natural History.								
19	TUESDAY,										
20	WEDNESDAY,										
21	THURSDAY,										
22	FRIDAY,										
25	MONDAY,										
26	TUESDAY,										
27	WEDNESDAY,										
28	THURSDAY,										
29	FRIDAY,										
1	MONDAY,	Examination by the Professor of Natural History.	Theatre of the Royal Dublin Society.	Examination by the Professor of Natural History.	Theatre of the Royal Dublin Society.	Examination by the Professor of Natural History.	Theatre of the Royal Dublin Society.				

## JUNE.

## GENERAL EXAMINATIONS.

WEDNESDAY, June 3, General Examination by the Professor of Physics.

THURSDAY, " 4, " " Professor of Chemistry.

FRIDAY, " 5, " " Professor of Natural History.

SATURDAY, " 6, " " Professor of Geology.

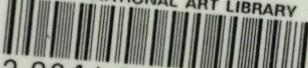
THURSDAY, " 11, The prizes and certificates awarded at the several Examinations will be publicly conferred, and the Session closed with an Address by the Director, Sir Robert Kane.



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To Herr Major, Swiss Guard Officer.